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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY JANUARY 1984 $3.00

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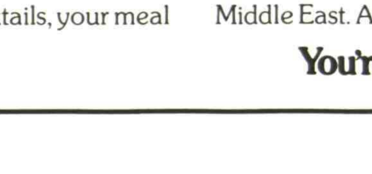

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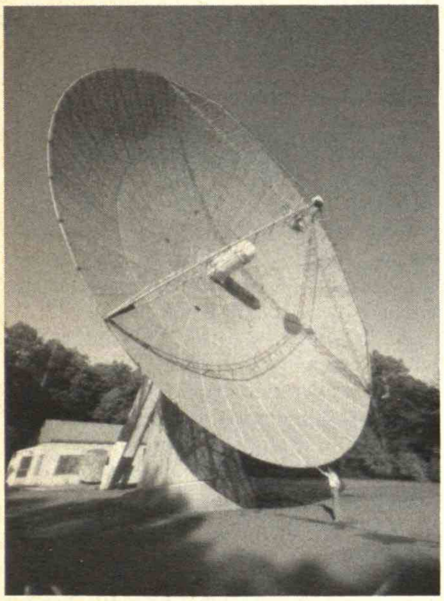

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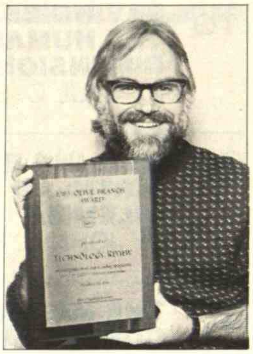
Peace Prize

Technology Review has won a 1983 Olive Branch award for its coverage of nuclear disarmament. The prize, presented by the Editors' Organizing Committee and the Writers' and Publishers' Alliance for Disarmament, recognized the Forum section in the February/ March 1983 issue. Assembled and edited by Senior Editor Tom Burroughs, the section contained three articles: one on the psychology of war and peace by Judd Marmor; one on business deals with the Soviets by Alan F. Kay; and one on the perils of defense employment by Warren F. Davis.


Tom Burroughs

Technology Review kept good company. The 9 other winners of Olive Branch awards, out of 58 entrants, included *Foreign Policy*, the *New Yorker*, and *Scientific American.—Peter Gwynne*

Fusion: Pros and Confusion

Lawrence Lidsky's negative and sensationalist presentation of fusion (*"The Trouble with Fusion," October, page 32*) does a disservice to thousands of competent scientists and engineers working on fusion around the world. This community has been concerned with the problems Lidsky raises. However, it does not share his conclusion that the problems cannot be solved. Indeed, many studies show that the economics of fusion, though uncertain, are within range of projections for fission and other power sources in the next century.
Stephen O. Dean
Gaithersburg, Md.

Stephen O. Dean is president of Fusion Power Associates.

There is ample room for discussion about the technical problems of existing light-water reactors, and Lidsky is probably correct that fusion, as currently envisioned, would not be a technical or economic improvement. However, the public's ultimate perception of fusion as dangerous would be a far more significant problem and one difficult for scientists to address.

For example, almost a third of my students believe that today's nuclear power plants can explode like a nuclear bomb. Recent surveys reveal that the general public also believes this physical impossibility could occur. Thus, public opposition to this power source is not surprising. The general public also believes that disposing of waste from fission reactors is an insoluble technical problem.

The word radioactive still frightens people. If by some technical miracle the problems with deuterium-tritium reactors were solved, there would still be difficulties with public acceptance.
William D. Walker
Durham, N. C.

William Walker is professor of physics at Duke University.

I must take exception to Lidsky's assertion that "early schemes for disposal of fission wastes had to be inexpensive to allow the reactors to compete"; that these schemes included "dumping them on the ocean bottom or injecting them into underground strata"; and that "the fission community did its reputation lasting damage by advocating them."

Readers might rightfully be confused by what is meant by "fission wastes." The nuclear power industry produces a variety of wastes ranging from highly radioactive spent fuel to marginally contaminated industrial trash. Early proposals for disposing of these wastes generally varied with the degree of hazard, not an unreasonable approach.

As one who developed vitreous matrices for disposing of high-activity fission wastes at M.I.T. in 1956, I presume I am a long-time member of the "fission community." However, to my knowledge, no segment of that community ever "advocated" dumping these wastes on the ocean bottom, although packaged low-level wastes were so disposed of with no biological harm. This practice continues in Europe.

The National Academy of Sciences has twice considered the alternative of injecting high-activity wastes into underground strata, both times calling for more research and development and approving alternative proposals. For example, the Department of Energy is proceeding with the

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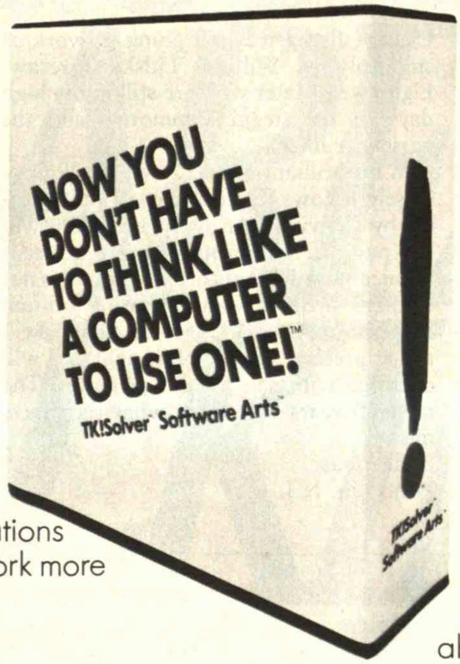

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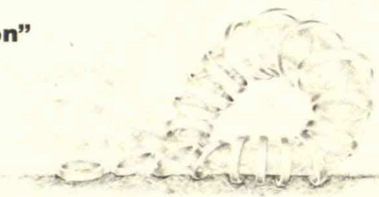
Defense Waste Processing Facility, a vitrification process, at the Savannah River Plant.
Morton I. Goldman
Gaithersburg, Md.

In the early twentieth century, when the Wright brothers were preparing for Kitty Hawk, one William Lidsky wrote an article in a prestigious journal. Lidsky was very critical of the Wrights' plan to use an airscrew, or propeller, and showed that jet engines provide the only economical power for large-scale commercial flights. He also showed that fuel for jet engines would be much safer than gasoline for propeller engines.

The Wright brothers agreed with the author. They had not yet made their firs flight and thus could redirect their research toward jet planes. But they found rather quickly that jet engines need special high-temperature and high-strength materials that did not yet exist, nor had inconels and hastalloys been developed. Clearly, flying was not going to work as smoothly as William Lidsky foresaw. Eighty years later we were still in the high days of the steam locomotive and the passenger liner.

In his brilliant article, Lawrence Lidsky closely follows the footsteps of his ancestor by showing that hydrogen fusion will not pay off. The proper way to get economical fusion plants off the ground is not through hydrogen but by using lithium and boron. Of course, some people will not appreciate Lidsky's foresight and will continue with the present program. The next 80 years will show what they have missed.
E. de Haas
Princeton, N.J.

Trouble with "The Trouble with Fusion"



In "The Trouble with Fusion," Lawrence Lidsky proposes that neutron-producing reactors will not be wanted, and that neutron-free reactors offer the only real hope for fusion. While acknowledging some very challenging technical problems, I believe that Lidsky's excessive pessimism about neutron-producing reactors is unjustified and is based upon an imbalanced assessment.

Environmental Impact

The products of fusion reactions do not have long-lived radioactivity, and long-lived radioactive wastes could be virtually eliminated from neutron-producing reactors if appropriate structural materials are used. A hundred years after shutdown, the biological hazard of the radioactive waste in a fusion plant would be more than a million times lower than that of a comparable fission plant. Furthermore, fusion reactors would have inherent safety features. A major amount of energy could not be released from the small amount of plasma fuel. There would be very low afterheat in the structure, greatly reduced radioactivity, and no physical mechanism that could cause a catastrophic meltdown type of accident.

Lidsky describes but doesn't adequately emphasize these potential advantages. He does not recognize that they could be very important in future public decisions on energy sources. Opposition to transporting and storing of radioactive waste has increased, and fission plants have been threatened with shutdown because of public concern about evacuation in the event of a worst-case accident. There are also a number of problems connected with the use of coal-fired power plants, including the greenhouse effect and acid rain.

To downplay the advantages of fusion, Lidsky argues that "fusion's neutrons could easily be used to manufacture material for atomic weapons." However, standard operation of a fusion electric power reactor would not produce material that could be used for nuclear weapons. Thus, nuclear materials could not be stolen from fusion plants or supporting fuel-cycle facilities. Moreover, any government seeking to begin producing nuclear weapons could more readily make use of existing approaches, including fission reactors and centrifuges.

Capital Cost

Lidsky implies that because of the low reactor power density (the rate of energy production per unit of reactor volume), the capital cost of a fusion plant would be much higher than the cost of a fission plant. However, this argument applies only to the cost of the reactor itself. The costs of plant components other than the reactor, such as turbines, heat exchangers, and buildings, are substantial. These "balance-of-plant" costs would be similar in fusion and fission power plants. In a fission plant, the "balance-of-plant" is a much larger component of the total cost than the reactor. Therefore, even if the cost of the reactor in a fusion plant is substantially higher than the cost of the reactor in a fission plant, the total cost of a fusion plant will not be proportionately greater.

Estimates for present designs indicate that the capital cost of a fusion plant would be about two times greater than that of a comparable light-water fission plant. When the very low cost of fusion fuels is taken into account, the cost of electricity from a fusion plant would be about the same as the cost of electricity from a nonbreeding fission reactor, which, as a long-term energy source, uses expensive uranium. (Lidsky mentions that, for the long-term, uranium could be obtained from seawater. However, it is interesting to note that fission of the uranium in 10 million gallons of seawater can produce only about the same amount of energy as fusion of the deuterium in 1 gallon of seawater.)

Furthermore, it is important to note that the relative economics of fusion, fission, and other long-term energy sources will be sensitive to requirements of environmental acceptability. Thus, true comparison of power costs is much more complex than Lidsky suggests. His emphasis on reactor power density is an overly simplistic argument that would also rule out another long-term energy option—solar photovoltaic power.

Plant Availability

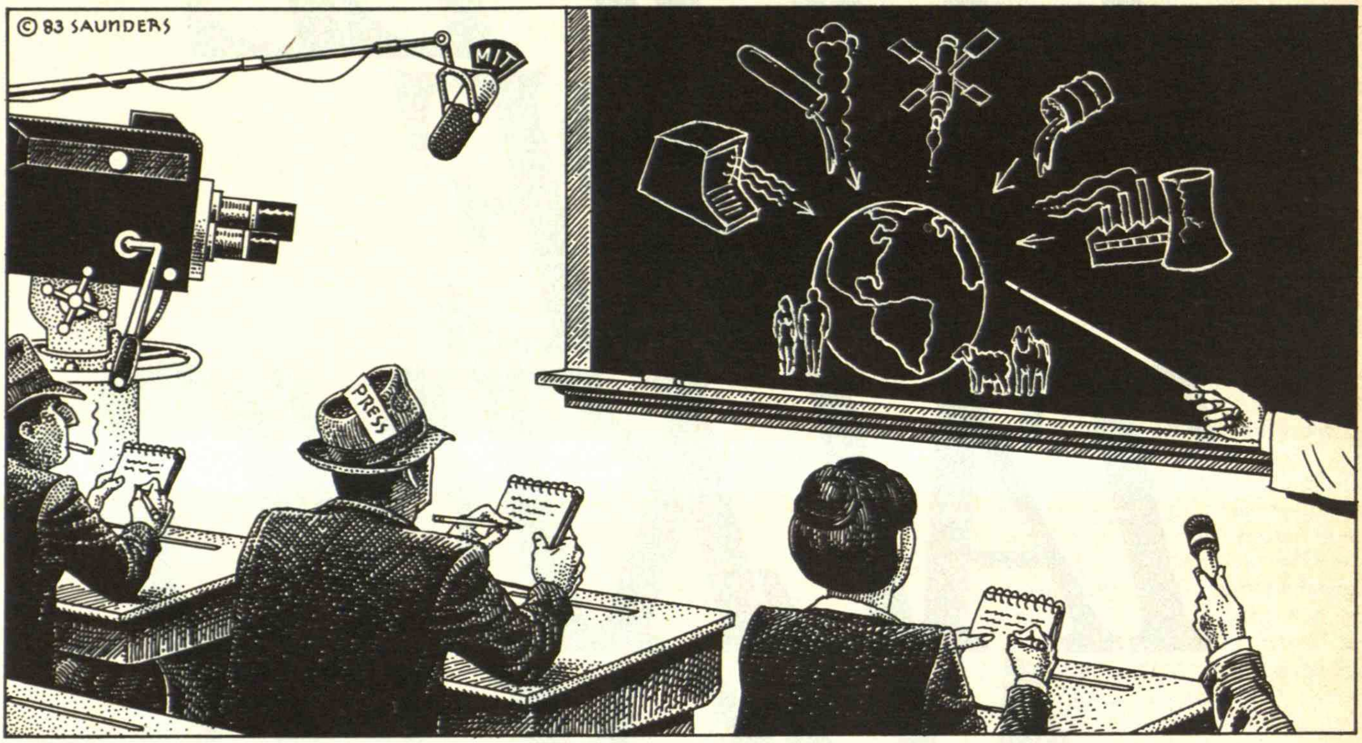
Lidsky's concerns about the availability of fusion plants are well founded. The cost of electricity would be unacceptably high from any plant that operated only a small fraction of the time. This problem is well known and is being addressed.

Neutron damage is an important limit on first-wall life but not a prohibitive one. The life of the first wall is estimated

Continued on page 63

ROBERT C. COWEN

Avant-Garde Science Journalism



THIS is an unabashed commercial for a series of experiments to aid public understanding of science. In the past three years, new programs for science journalists have sprung up across academia.

For example, eight seasoned science journalists from print and electronic media are spending the 1983-84 academic year at M.I.T. as Vannevar Bush fellows. Along with Victor McElheny, the curator of the program, this pioneering group is setting precedents for what can become a unique educational opportunity, both for the journalists and for the M.I.T. community. The fellows are inquisitive, skeptical, and likely to challenge cherished assumptions about the nobility of research and the value of technological "progress."

A handful of science graduates is picking up the art of writing about science and technology at Stanford University. Under the guidance of Joel Shurkin, the students are writing news releases and articles for the school newspaper and departmental publications. Thus, the group is experiencing firsthand the joys and frustrations of bridging the gap between the technical community and the public.

ROBERT C. COWEN is science editor of the *Christian Science Monitor* and former president of the National Association of Science Writers.

Drexel University, Duke University, Johns Hopkins University, New York University, and the University of California at Santa Cruz all offer new graduate programs in science writing. The students—most of whom majored in science and engineering as undergraduates—learn that translating complex technical topics for lay readers, viewers, and listeners demands more than simple familiarity with the subject matter.

The professional journalists in the Bush fellowship program at M.I.T. face some stiff challenges of their own. They have plunged into an environment where understanding a scientific or technological development more or less correctly in a loose, qualitative way just isn't good enough. Glib assumptions about the social myopia of the scientific and technological community are naive. The widespread tendency of the press to take a simplistic view of emotional but technically complex issues, such as the dangers of acid rain or the safety of nuclear power, is becoming an embarrassment.

Eight decades into a century that has brought the social issues of science to the forefront, it is time for the complementary perspectives of scientists and the public to confront each other. To be sure, scientists have paid a great deal of attention to the public's perception of their work at various times and in various ways. Yet, with due respect for good intentions, the general attitude of scientists and engineers toward the press, which is the mediator, has been patronizing.

Dawn of Science Journalism

The spread of campus interest in science writing coincides with what, for me, are two relevant anniversaries. Fifty years ago in 1934, the formation of the National Association of Science Writers (NASW) marked the coming of age of science journalism in the United States. Last year was also the seventy-fifth anniversary of the founding of the newspaper for which I work. I was asked to review our coverage of science and technology in the light of world history over that span of time. I found that the public perception of science and technology has become crucial both to the health of the scientific enterprise,

ILLUSTRATION: ROB SAUNDERS

and to the technological strength the nation derives from it.

There was little to foreshadow this in newspaper science reporting 75 years ago. By 1908, Einstein had published the Special Theory of Relativity and his ideas about the quantum nature of light. Bohr was soon to propose his famous first concept of the quantized atom. These discoveries fundamentally changed scientists' concepts of the physical universe and made their work unexpectedly relevant to public affairs: they led to the atom bomb. Yet coverage of science such as there was focused more on geographical exploration and on the technology of the new aircraft and similar practical wonders. Bringing the more portentous trends forcefully to public attention required the rise of professional science journalists—men and women who combined reporters' skills with the knowledge and insight to penetrate the arcane scientific world.

By 1934, the profession was strongly enough established for the science writers of the wire services and several major newspapers, including my predecessor at the *Christian Science Monitor*, Herbert B. Nichols, to establish the NASW. The profession has flourished ever since.

Much of the reporting of the 1920s and 1930s had a "wonders-of-science" flavor, an outlook typical of scientists themselves at that time. Yet there were darker undertones. There were enough hints of the possible practical uses, especially military uses, of nuclear fission for a perceptive science reporter such as William L. Laurence of the *New York Times* to sniff out the trail of the bomb until he joined the Manhattan Project as its official scribe.

By the eve of World War II, the news media had begun to report the concern that at least a few scientists felt for the larger impact of their work. News accounts echoed the warning of *Nature* editor Sir Richard Gregory that "it would be a betrayal of the scientific movement if scientific workers failed to play an active part in solving the social problems they are partly responsible for."

Yet although the mushroom clouds over Hiroshima and Nagasaki drove this point home with a vengeance, many scientists and some science writers were reluctant to take it, even as some scientists and engineers refuse to face up to it today. When I joined the profession in 1950, fresh out of M.I.T., I was often warned by some of my science-writer elders to stick to the discoveries of the laboratory and leave "philosophy" to the political reporters.

Broadening the Vision

But some giants of the field thought otherwise. Britain's great science writers, Arthur Clarke and the late Lord Ritchie Calder, advised a young science journalist to "muck into" the social issues. So, too, did some farsighted scientific leaders such as Karl T. Compton, then chairman of the M.I.T. Corporation. He urged me to abandon a fully funded Ph.D. program to become a science journalist when the opportunity opened. He said he considered it far more important to contribute to an informed public understanding of science than to add one more statistic to the roster of M.I.T. Ph.D.s. And Harvard president James B. Conant told anyone who would listen that, far from anticipating a new age of abundance based on cheap atomic power, he foresaw "worried humanity endeavoring by one political device or another to find a way out of the atomic age." He encouraged reporters bemused by the technologists' dreams not to share their tunnel vision.

Gradually through the 1950s and early 1960s, the vision of the Clarkes, Comptons, and Conants came to be widely, if not universally, shared within the scientific and science journalism communities. Organizations such as the American Association for the Advancement of Science (AAAS), the American Chemical Society, the American Institute of Physics, and the National Academy of Sciences provided leadership by insisting that their members have a professional obligation to foster public understanding of science. The press facilities the societies provide at their meetings and the educational seminars some have offered to science journalists have been a valuable practical expression of that commitment. The NASW, too, has emphasized the larger perspective. It is no accident that, when it established a professional award, the association did so to honor outstanding reporting on the social impact of science and technology.

Indeed, wider implications of science and engineering simply could not be ignored by some parts of the scientific community. The AAAS had to enter the political and social arena in the 1950s when the outside world dramatically invaded its meetings—as when congressional witch hunters denounced AAAS president Edward Condon as "disloyal" in 1954. The recent awareness of widespread environmental decay owing partly to misused technology, and the political curtailment of research funding, have been needed to awaken a social consciousness in the rest of the scientific community.

As scientists have become more socially aware over the past three decades, a small band of U.S. science journalists has tried to give the public a sensible view of science and technology. Whether their work has made a major difference in improving the public's understanding of these fields is hard to determine. But this reporting usually stands in stark contrast to the simplistic fluff that often passes for science journalism in the printed and electronic media today. Such is the tradition from which the first Bush fellows have come to join the M.I.T. community. Their presence should be stimulating. □

Disasters and Decision Making

WHEN a section of interstate highway 95 plunged 70 feet into Connecticut's Mianus River last June, there was widespread relief that the accident killed only three people. If the bridge had fallen during the day instead of 1:30 A.M., the carnage would have been horrible beyond imagining. However, public concern seems to have subsided rather quickly, and if the nonchalance is related to the low death toll, then perhaps the blessing must be considered mixed.

No right-thinking person wishes for casualties to make a point. I recall the revulsion with which I read a recent article by an antinuclear advocate entitled "What This Country Needs Is a Meltdown." But there is no denying that in the absence of outrage, many things are ignored that deserve attention, and nothing produces outrage as readily as large numbers of innocent civilian deaths.

From 1825 to 1830 there were 42 recorded boiler explosions aboard American steamboats, each one killing an average of 6 to 7 people. But when in 1830 more than 50 passengers were killed by one explosion aboard the *Helen McGregor* near Memphis, public indignation finally reached the point where Congress was obliged to take action. The result was the first grant for technological research made by the federal government, followed in due course by regulatory legislation. Of course, the evolution of moral, social, and political values depends upon more than disasters. In mid-nineteenth-century America, the public was beginning to accept the idea of government responsibility for the safety of its citizens. But without attention-demanding events such as the *Helen McGregor* explosion, the translation of concept to practice can be unduly prolonged.

In our own time, the National Dam Safety Act of 1972 was passed after 125 lives were lost in the failure of a coal-tailings dam at Buffalo Creek, W.Va. As memory of the disaster faded, however, the inspection program mandated by the legislation was not funded. Inevitably, there was another catastrophe: in 1977, 39 students and teachers at a Bible college died in a dam failure at Toccoa, Ga. Then, and only then, did Congress vote funding for the program it had instigated five years earlier.

SAMUEL C. FLORMAN, a civil engineer, is author of *Engineering and the Liberal Arts, The Existential Pleasures of Engineering*, and *Blaming Technology*.

Repair Overkill

It is not only the number of dead that gives an event its shock value. In May 1979 a piece of masonry fell from the facade of a building in New York City and struck a young woman on the head, killing her. The building was owned by Columbia University and the victim was a student at Barnard College, which adjoins the Columbia campus. The event made headlines for several days. Stories about the tragedy were followed by reports about dangers inherent in the city's aging buildings. Public concern led to demands for action, and early in 1980 the city council enacted Local Law 10.

The statute requires owners of large buildings to have the facades inspected every five years by a licensed architect or engineer, and to promptly repair any potentially unsafe conditions discovered. In this case, although only a single life was lost, the "dread" factor was extraordinarily high. The death of a student at an elite women's college—all that vitality and promise snuffed out—has news appeal. Also, every resident of a city who walks its streets wants to be protected from falling masonry. Another reason for the new law's popularity was the fact that it entailed no cost to the taxpayers—all expenses are to be borne by landlords.

Whatever the public chemistry of this event, it clearly led to effective action. In fact, as the repair program progresses, questions have been raised about whether it is an overreaction. Hundreds of millions of dollars are being allocated for restoration work. Columbia University alone is spending 17 million dollars on its buildings. Real-estate analysts warn that the additional expense may prove ruinous to some property owners. Aesthetes and preservationists are also evincing alarm as decorative friezes are being removed, sometimes to be replaced with ugly patchwork stucco. Subjected to a cost-benefit analysis, Local Law 10 would surely fail—there is no logical basis for spending hundreds of millions of dollars to save perhaps one life every few years. Or, to put it more humanely, if we are interested in saving lives, there are far better ways of spending hundreds of millions of dollars. But we refuse to be intimidated by the mathematics of risk and analysis; we simply will not tolerate buildings crumbling above our heads.

So New York City's buildings are being inspected and repaired, and the nation's dams as well, each program the result of dramatic accidents that captured, more

ILLUSTRATION: JANE BIANCO

than fleetingly, the attention of an often fickle public.

Mundane Maintenance

The collapse of the I-95 bridge, however, does not appear to be an event of lasting impact. Although there were some negative comments about the span's outdated design, which relies upon a pin-and-hanger assembly, the basic cause of failure lies with inadequate inspection and maintenance, and that doesn't make very good newspaper copy. Since only three people were killed, public reaction has so far centered mainly on the traffic problems that developed while the road was out of service. True, the state of Connecticut has resolved to improve its bridge-inspection procedures, and across the nation there has been a momentary flurry of concern. But the basic problem remains unchanged.

According to the National Highway Traffic Safety Administration, half of the nation's 565,000 bridges are potentially unsafe. Indeed, about 150 bridges are washed away by floods each year, and an equal number simply sag, buckle, or collapse. But these failures occur without loss of life—at least they have since 1967, when a span across the Ohio River between Point Pleasant, W.Va., and Kanauga, Ohio, carried 46 people to their deaths.

The issue of maintaining bridges is so mundane that our society seems incapable of paying it heed. Yet this very mundaneness is what makes the neglect so disgraceful. The worst kind of failures, the most inexcusable, are those that stem not from ignorance or bad luck but rather from carelessness and boredom. The inspection, maintenance, and repair of bridges is neither glamorous nor newsworthy. Yet it is appalling to think that this important work might languish until a suitably shocking disaster occurs.

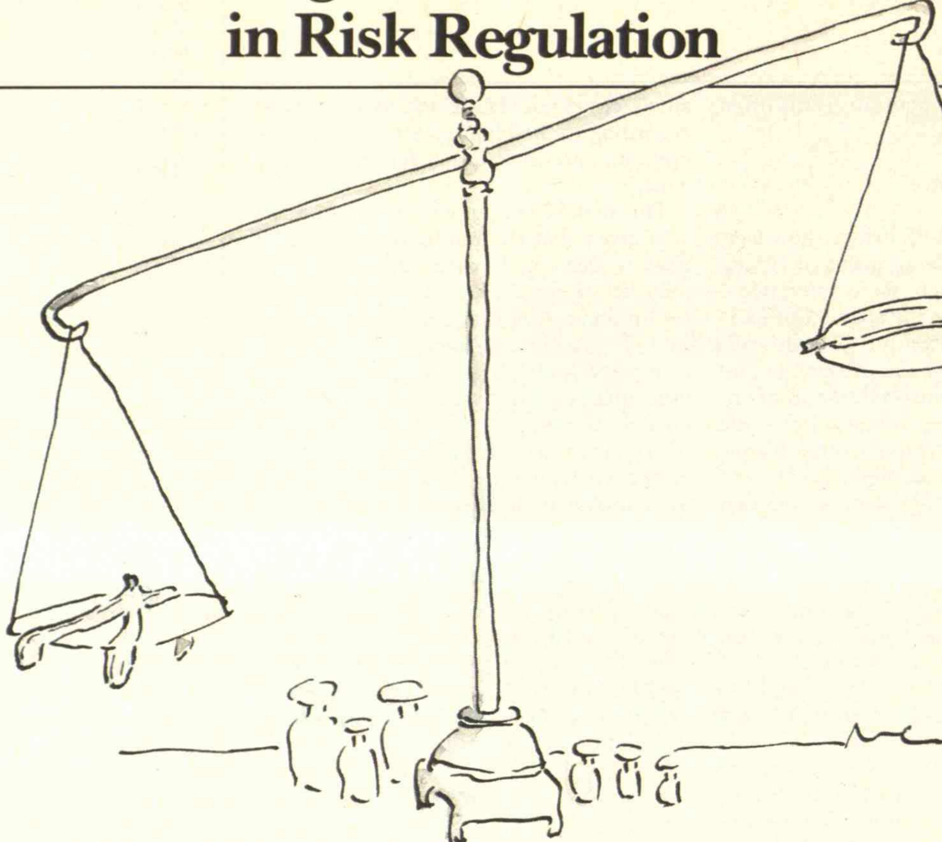
After the London smog of 1952, a catastrophe held responsible for 4,000 deaths, an investigating committee was established, chaired by Sir Hugh E.C. Beaver. The committee's report was well-received and led to an effective antipollution law, not because the investigators' work was in any way exceptional but because the public mood was propitious. For 700 years, attempts had been made to clean London's air, but commission after commission had failed to gain any result. Disaster finally achieved what sensible advice could not. The lesson to be learned, according to Sir Hugh, is that "on public opinion, and on it alone, finally rests the issue."

This may be so, but we need not accept as a given that the public will always be deaf to reasoned warnings, responsive only to shock. As our society faces the continuing deterioration of its "infrastructure," a cadre of concerned citizens—engineers foremost among them—must urge proper action and persist when rebuffed. Where the community remains indifferent and politicians evasive, public-works engineers have no choice but to redouble their efforts, doing the best they can with curtailed budgets and inadequate staff.

Engineers, being human, are also susceptible to the drowsiness that comes in the absence of crisis. Perhaps one definition of a professional is that of a person who stays alert while others doze, whose sense of responsibility does not require the stimulation of catastrophe ☐

BY PETER HUBER

Discarding the Double Standard in Risk Regulation



THE regulation of risk as presently conducted by our federal government not only aggravates the hazards it's supposed to avoid, but stands as a major obstacle to technological innovation. New products are regulated much more strictly than older ones, impeding efforts to improve technology. The remedy lies in a greater emphasis on comparative risk regulation.

We all know that risk is ubiquitous. Cataloguing the risks of daily life has become something of a sport. And although insurance companies know that life is getting progressively safer, the public is firmly convinced that life is becoming ever more hazardous. Congress, understandably enough, is more interested in the opinion polls than in the actuarial tables. A large body of legislation reflects the popular concern.

The major "environmental" statutes of the last two decades—the Clean Air Act, the Federal Water Pollution Control Act, the Resource Conservation and Recovery Act, and the Toxic Substances Control Act—are directed primarily at controlling the adverse health effects of air, water, and land pollution. The risks of food and drugs are also heavily regulated, as are the risks of transporting people and hazardous cargoes. Consumer products are regulated through special-purpose statutes covering flammable fabrics, poisons, lead paint, and other hazardous household substances.

Beneath the surface of this legislation lie not one but two bodies of law. On the one hand, we have made a modest federal commitment to reducing the "old" risks of our environment such as driving a car, digging for coal, eating a sandwich, and stepping out for a breath of air. On the other hand, we have made a strong federal commitment to resisting technological changes that threaten to introduce "new" hazards into our lives. I have in mind here risks associated with nuclear power, artificial food additives, and new toxic chemicals.

The Dual Approach to Risk

These two commitments are different. Concern over "old risks" generates laws that demand a change in the established order, or "cleanup" legislation. Focus on "new risks" generates laws that demand preservation of the presumptively safe status quo, or "antilittering" programs.

These two objectives yield two very different regulatory procedures: "standard setting" and "screening." Standard setting is regulation by fiat from Washington. You go about your business until Washington, in its own good time, comes to you and tells you how to do it better. Screening is regulation by advance permission. Before you're allowed to do something, you go to Washington, hat in hand, and ask for a license.

For example, the Occupational Safety and Health Administration (OSHA) sets standards to improve workplace safety. The Food and Drug Administration (FDA) screens food additives. Both agencies often deal with biologically similar toxins such as chemical carcinogens. But they do so using fundamentally different regulatory tools.

Standard-setting agencies drag us slowly and usually reluctantly into a safer world, driving out the devils we know. Screening agencies act as guardians at the gate, making yes-no kinds of decisions, protecting us from the ominous unknown.

As a general rule, standard setting is reserved for old risks—risks to which society has already been widely exposed before the decision to regulate is reached. Screening is applied to new risks that

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ILLUSTRATION: MICHAEL CRAWFORD

Standard-setting agencies drag us reluctantly into a safer world, driving out the devils we know.

loom on the horizon—risks that threaten to undermine the perceived safety of the status quo. We set standards to control the hazards of burning coal in old plants, but we screen new nuclear power plants. The Environmental Protection Agency (EPA) screens the production of all major new chemicals. But it merely sets standards for producing and handling old ones. The EPA screens new pesticides but with rare exceptions does nothing with old ones.

This division, however, isn't as neat as it might be. The FDA, a screening agency, must regulate both old and new food hazards. And OSHA, a standard-setting agency, must regulate both old and new workplace risks. But the old-new division is invariably codified at a second level as well—within each agency's charter. For example, the FDA's regulation of foods is rigidly subdivided between natural foods, which are, of course, "old"; food additives, which are usually "new"; and a curious group of substances known as GRAS substances. GRAS is an acronym for "generally recognized as safe," and GRAS substances are food additives identified as safe in an informal poll of the scientific community conducted by the FDA in the late 1950s. Numerous other risk statutes contain similar divisions.

The Result: Skewed Regulation

This double standard in the way we regulate old and new risks has profound results:

☐ Screening systems regulate at the "strict" margin of scientific uncertainty, standard-setting systems at the lenient margin. Screening thus admits only the "acceptably safe"; standard setting regulates only the "unacceptably hazardous." There is often a wide gap between these two criteria.

☐ While screening systems place the cost of acquiring the information needed for regulation on the regulatee, standard-setting systems place that cost on the agency. This makes all the difference when the product or process targeted for regulation is only marginally profitable. Pesticide manufacturers who must spend $20 million on tests needed for licensing will never even submit a product for review, regardless of its safety, if they stand to make only $19 million from its sale.

☐ As a result, screening systems tend to favor big-ticket products and operations, such as broad-spectrum drugs, large nuclear power plants, and nonspecific pesticides. Securing regulatory approval of a single 1,000-megawatt power plant will certainly cost less than securing approval of two 500-megawatt plants. In contrast, standard-setting systems tend to place the greatest burdens on the largest regulatory targets because that's where the standard-setting agency can have the biggest impact. A small generator of an unusual type of risk is often beneath the standard-setting agency's attention.

☐ Screening systems place the often considerable cost of regulatory delay on the regulatee. Standard-setting delays postpone the cost of compliance—for a long time if the regulatees have a good lawyer on their side.

☐ The final and most important difference between the regulation of old and new risks is found in the statutory criteria for regulation. Standard-setting statutes always limit the costs that a regulatory scheme may impose on regulatees. Screening statutes rarely contain analogous provisions. The Nuclear Regulatory Commission (NRC) is not required to consider economic impacts when it withholds the Diablo Canyon license, or, for that matter, when it freezes out all future development of nuclear power. In contrast, OSHA standards may not be so strict that the costs of compliance threaten the existence of the industry regulated.

Why does this double standard exist? The reason, I'm convinced, is very simple: Congress realizes that it's economically and politically expensive to regulate old risks, but believes it's relatively cheap to regulate new ones.

That belief is understandable enough. Cleaning up the risk environment requires direct cash outlays. Regulated industries don't like these transition costs, and consumers get particularly upset when they lose old products they have become used to. In contrast, regulating new risks attracts much less political heat. Manufacturers don't have to adjust production processes, and consumers don't have to change established patterns of consumption.

But the prevailing belief that it is cheaper to exclude one unit of new risk than to protect against one unit of old risk is wrong. Lost opportunity costs are not always negligible. To cite just one example, uniquely therapeutic drugs are often licensed in this country years after they are approved elsewhere. The people who lose the opportunity to be treated in the interim pay a very real price. More generally, this misapprehension of costs reflects the alarming view that there is little to be gained through technological and scientific progress.

Fueled by the widely held belief that life is too dangerous, this bias against new sources of risk is a recipe for technological regression. The products or activities most secure from regulatory extermination are those most widely used—typically old products that have become entrenched. Thus, regulation shuns the novel and innovative in favor of the familiar.

A Uniform Approach to Risk

What is to be done? I believe there is a politically feasible alternative: comparative risk regulation. Although most people think that new products and processes add to society's risk burden, in reality most new products don't "add to," they "substitute for." Yet regulatory agencies are prohibited from comparing the risks of a new product with the risks of the old ones for which it will substitute. Instead, regulators are called upon to make absolute determinations of safety within the "old" or "new" risk categories.

Exacerbating the problem, different agencies regulate risks that sensibly belong under a single regulatory umbrella. For example, the NRC has become expert at estimating the risks of nuclear power, but the agency has no mandate to compare these risks with those of alternative energy sources. Meanwhile, the EPA (which regulates the alternatives) devotes vastly fewer resources to assessing the risks of those alternatives, such as coal power. The result: we know too much about the risks of nuclear power and too little about the risks of other energy technologies. To the uninformed, this has quickly translated into the conviction that nuclear power is more dangerous than its alternatives.

A comparative approach to risk regulation would assume that most technologies are substitutes, not additions. It would also dovetail neatly with our reluctance to regulate old risks precipitously. Once we determine that an old product or activity is tolerably safe, it could provide the reference point of "acceptability" by which alternatives would be judged. Comparative

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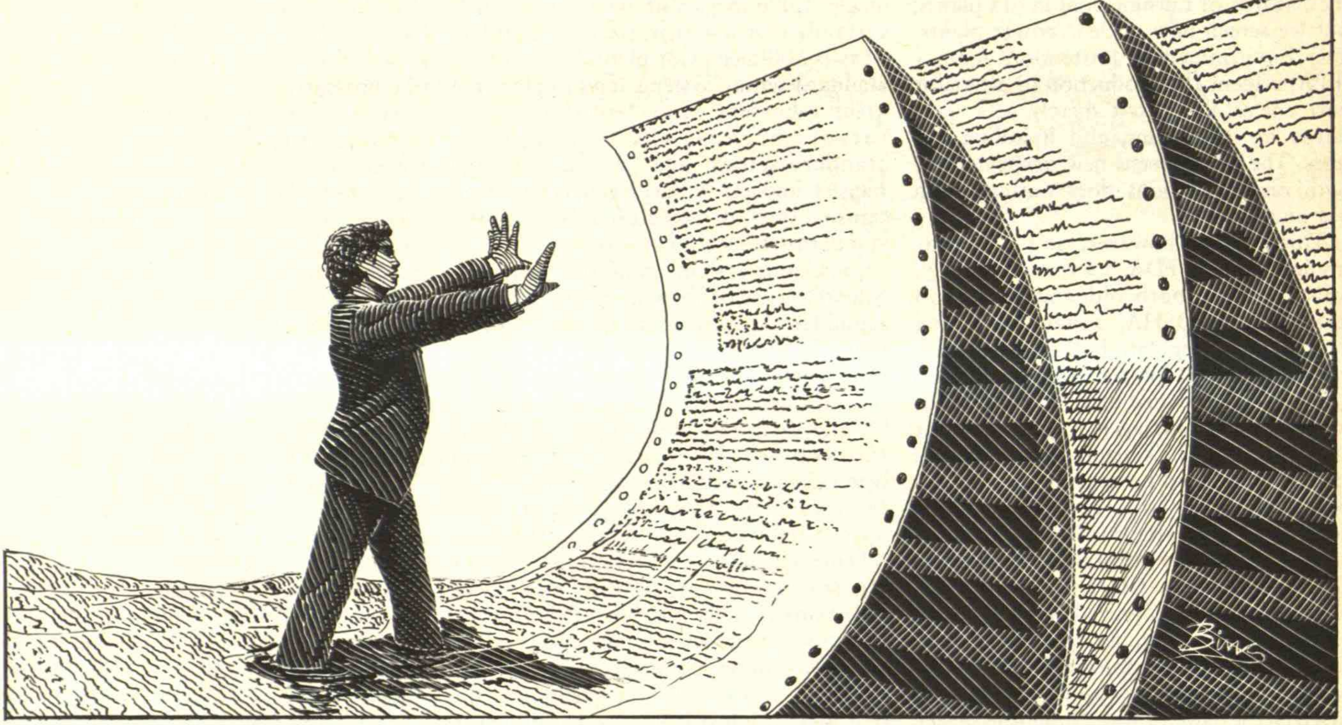
FORUM

BY HARLAN CLEVELAND

King Canute and the Information Resource



SOME people collect coins or stamps or forgeries of Salvador Dali paintings. I have taken to collecting Canutes—instances of behavior reminiscent of the legendary Danish monarch, who stood on the beach and commanded the tides to stand still as proof of his power. (Revisionist historians say King Canute really stood on the beach for a "wetting—an object lesson in humility." But his name has gone down in history as a metaphor for futile efforts to avoid change.)

The information environment created by the explosive convergence of computers and modern telecommunications is full of examples of Canutish behavior. The trouble seems to be that we have carried over into our thinking about information concepts that used to work pretty well for the management of material things. But information (as enhanced by modern telecommunications and fast computers) is such a different kind of resource that our traditional ideas about "control" and ownership" are somehow transmuted into folly.

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Unlike coal, automobiles, food, or clothing, information is expandable (it grows with use, enhances its value through dissemination), diffusive (it leaks and is therefore harder to hide), and shareable (if I give you food or sell you an automobile, you have it and I don't; if I give you a fact or sell you an idea, we both have it).

The propensity of information to leak is like waves eating away the foundations of a seashore condominium, eroding the doctrine that information can be owned, exchanged, and monopolized the way "real" resources can. Those who persist in treating information as property—here or abroad—are likely to get wet.

The Breakdown of Copyright Laws

The entrepreneurs of high technology keep developing better and faster techniques of pirating information—xerography, videotapes, the backyard dish for picking up signals from satellites. The knowledge explosion has also produced new kinds of works (computer software) and means of delivery (microfiche, video cassettes, computerized databases). Laws written to protect books, phonograph records, and broadcasts—the products of the past—are becoming harder and harder to apply.

Yet Canutes persevere. The Association of American Publishers sued New York University and nine professors for infringing copyright when they copy literature to help students learn. In the end, the publishers had to settle for vague promises that the university would be good; they didn't even get their court costs back. The folks who own Home Box Office think it's bad taste for homeowners to build receiving stations on their roofs to capture HBO signals floating on the public's airwaves. And Universal City Studios is still trying to get Sony to stop selling videotape recorders for use by people in their living rooms. Not only that, but a panel of federal judges in the Ninth Circuit agreed

ILLUSTRATION: CHRISTOPHER BING

The leakiness of information seems destined to overwhelm the Canutish efforts to imprison it.

with Universal, in an opinion that for sheer effrontery to common sense rates the Kind Canute prize for 1982: "Off-the-air copying of copyrighted materials by owners of videotape recorders in their homes for private noncommercial use constitutes an infringement of copyrighted audiovisual materials."

Sometimes the law seems to be like Kipling's "elephant's child," its nose pulled out of shape by the crocodile of reality. I have struggled through the densely legalistic prose of Universal City v. Sony, and diagnosed the appeals judges' problem: a dynamic technological environment makes them acutely uncomfortable. In the tradition of the law, which looks backward at past legislative actions, they hitched their wagon to what Congress meant to say about technologies it couldn't yet imagine.

The Supreme Court has agreed to review the case, thus giving itself a chance to show that horse sense is not necessarily incompatible with the law. Lao Tzu had some advice that may help: "*To know that you do not know is the best. To pretend to know when you do not is a disease.*"

The Technological Fix

The nervous breakdown of copyright protection may be retarded to some degree by technological fixes. Satellite broadcasters can scramble their signals to prevent pirating. The creators of some computer programs have devised elaborate codes, though teenage "computer hackers" have been showing how inherently porous they are. Recording your unique insights on videodisk may keep them a secret at least to people who cannot afford videodisk technology.

But the leakiness of the information resource seems destined to overwhelm the Canutish efforts to imprison it. The history of arms control and the recent efforts of teenage computer pirates teach us that there is always a technological fix for a technological fix.

We have long since abandoned the idea that intellectual creativity has to be rewarded with ownership. Most U.S. patents are held by organizations (corporations, universities, government agencies), not by inventors themselves. And many copyrights are held by publishers and promoters, not by the authors and songwriters the Founding Fathers may have had in mind when they sewed information-as-property into the Constitution. Creators, however, can and do still share in the profits through joint-venture arrangements or royalties.

Likewise, in U.S. universities, creative work is rewarded mostly by promotion, tenure, and tolerant attitudes toward minimal teaching loads and outside consulting. As a result, we generate a respectably innovative research and development effort without scientists' and inventors' having to "own" the ideas they contribute.

The leaders of industries on the high-tech frontier are already saying that their protection from overseas copyists doesn't lie in "trade secrets" but in healthy R&D budgets. John Rollwagen, chief executive of Cray Research, which produces the world's fastest computer, puts it this way: "By the time the Japanese have figured out how to build a Cray 1, we have to be well along in designing Cray 2—or we're out of business."

The notion of information as property is built deep into our country's laws, our economy, and our political psyche. But we must continue to develop better ways of rewarding intellectual labor without depending on copyright laws and prohibitions that are disintegrating fast—as the Volstead Act did in our earlier effort to enforce an unenforceable Prohibition.

The Politics of Information

In international politics, the doctrines affecting information are in complete disarray. Every newly miniaturized recording and every satellite launched for communication or remote sensing makes it more difficult to sustain the doctrine that national governments can own, or even control, their information resources.

In 1979, the U.S. government sent two delegations to two world meetings about the control of information. At a UNESCO conference in Paris, the instructed delegates righteously advocated the "free flow" of information—information furnished by U.S. news agencies, television producers, and movie studios. At the U.N. Conference on Science and Technology for Development in Vienna a few weeks later, an equally righteous group of instructed American scientists and technologists came out against the free flow of information—this time technological information we were anxious to hoard.

Both principles are authentically American: the right to choose, the right to own. In international discourse, we will hardly be able to have it both ways. Yet there is no evidence that the two groups of delegates, and the government that instructed them, perceived the irony or the contradiction.

If information is inherently hard to bottle up, policies based on a long-term monopoly are likely to have a short half-life. In our generation-long arms race with the Soviet Union, successive U.S. administrations have managed to persuade themselves that each new U.S. weapons system—its made-in-America technology a continuing mystery to our adversaries—would enable us to stay "ahead." In the most Canutish of these actions, the United States in the early 1970s decided to stuff multiple independently targetable reentry vehicles (MIRVs) into single missiles. Despite elaborate secrecy on our part, the Soviets soon figured out how to do likewise. But since they had built much bigger missiles boosted by more powerful rockets, they were able to stuff more MIRVs into their canisters than we could. Thus did we outsmart ourselves by taking an action that depended for its validity on technological secrecy, creating the famous "window of vulnerability."

For three decades, our government has also engaged in half-hearted efforts to bottle up "strategic" U.S. science and keep foreign nationals out of "sensitive" university research. The Reagan administration's efforts in this area have been the most vigorous yet. But these attempts are not working very well: Americans have no corner on the market for brains; scientists talk across frontiers to one another, and Soviet technological espionage has long been a thriving industry. Furthermore, our European allies never had much enthusiasm for controlling transborder information flows because sales of equipment mean jobs for Europeans.

Licensing Xerox Machines

Such government behavior seems to work better in totalitarian societies where keeping information from spreading is honored by doctrine and practiced ad absurdum. Xerox machines are still licensed by

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Screening agencies act as guardians at the gate, protecting us from the ominous unknown.

risk regulation would also make the process easier, since it is simpler to compare risks than to determine absolute safety. People would complain much less about research results based on overfeeding of rats if the data simply showed one group of live and healthy aspartame-fed rats and another group of dead or ailing saccharin-fed rats.

A comparative approach might also prevent regulation from aggravating the hazard that is supposed to be mitigated. Regulatory decisions that exclude a hazardous product but retain an even more hazardous one are counterproductive. For example, cyclamates have been banned in this country while saccharin has not been. Canada has followed exactly the opposite course. One of us has banned the safer product and continues to use the more hazardous one. Comparative regulation would impel agencies to confront such problems head-on.

To implement this comparative approach, we must restructure our regulatory agencies around natural "risk markets." For instance, regulation of all types of electric power should come under the jurisdiction of one agency. And within the agencies themselves, artificial divisions such as those between "natural foods" and food additives, old and new drugs, and old and new chemicals should be discarded.

The Argument Against Comparing Risks

Despite its obvious advantages, comparative risk regulation encounters deep-rooted opposition. The critics have two basic refrains: risks are unmeasurable, and risks are incommensurable. The "unmeasurability" argument usually goes like this: Risk estimates can't be trusted, so regulate according to maximum conceivable harm. Don't trust the experts. Expand the definition of risk to include all sociopolitical, biological, and geophysical conditions. Such arguments are, of course, intellectual rubbish. If risks are unmeasurable, then risk regulation is an utterly futile endeavor. Any engineer knows that you cannot control what you cannot measure.

Other critics argue that most risks are fundamentally incommensurable. Carcinogenic foods cannot be regulated according to the same criteria as noncarcinogenic but otherwise toxic foods; rare catastrophes must be regulated differently from common hazards; some technologies are more susceptible to sabotage and require special treatment. The only answer to this line of reasoning is that most people don't care whether they die from a common risk or a rare disaster—a life is a life. And for a government agency with limited administrative resources, excessive fragmentation of the risk universe is a recipe for utter paralyis.

The campaign against comparing risks, I believe, is driven largely by one reality, unacceptable to many: life is getting safer, and new products and processes are almost uniformly safer than the old ones they replace. Many people fear, perhaps with good reason, that a comparative approach to risk regulation will lead to regulatory choices that favor new technologies over old ones, capital-intensive technologies over labor-intensive technologies, and large-scale, centralized projects over small-scale, decentralized ones. There may be valid political and sociological reasons for resisting any or all of these trends. Those reasons, if they exist, should be aired in the appropriate political arenas. But they should not concern regulatory agencies, whose task must be to monitor and improve our risk environment. Measuring and comparing risks is no small task. Risk-regulating agencies should not be concerned with promoting jobs, allocating wealth, or tending to the psychological health of the nation.

Tax lawyers can regale you at great length with stories about the Internal Revenue Code. That code is so complex, so carefully tuned to account for every contingency, so replete with special provisions to deal with special cases, that an able tax lawyer can make it do almost anything for anyone. In their present forms, our risk statutes, too, can be used to achieve almost anything. They can enhance our risk environment, and sometimes they do. They can obstruct risk-reducing technological change, and often they do. They can depress technological innovation, and I believe they do that all the time.

We have all heard the proposals for a greatly simplified income tax: no deductions, no loopholes, no complications. The equivalent is comparative regulation, with a flat focus on risk and risk alone. This is the only approach that can be rationally implemented by our well-meaning but not omniscient regulatory agencies. □

In international politics, the doctrines affecting information are in complete disarray.

the government in the Soviet Union; in Bulgaria, even the use of typewriters is restricted. Ideas are harder to license. Russian and Bulgarian youngsters readily learn about blue jeans and hard rock, and scientists on both sides of the porous Curtain seem to know how far along their peers are in unraveling the puzzlements of space travel.

The good news is that sharing is the natural mode of scientific discovery and technological innovation. The new information environment seems bound to undermine the knowledge monopolies that totalitarian governments convert into monopolies of power. More and more information is leaking into the "Soviet bloc" via television, radio, and tourism. In the horoscope of the USSR, a future looms where nobody is in charge.

The "informatisation" of society may destabilize more than the Soviet bloc. It may help undermine the systems that keep 2 billion people in relative poverty worldwide—with more than a third in absolute poverty. In the industrial era, poverty was marked by an absence of things—minerals, foods and fibers, and human-made products. In the postindustrial era, these physical resources are joined at center stage by information, the resource that is harder for the rich and powerful to hoard. But whether the "informatisation" of the globe will make for a fairer distribution of its resources depends on the extent to which people in the traditionally "poor nations" are motivated (and allowed by their own suzerains) to educate themselves.

The key that unlocks "growth and fairness" in this changing context is the widespread delivery of relevant education. More than any other factor, it was that prescient nineteenth-century decision to offer free education to every citizen that enabled the United States to pull itself out of underdevelopment.

Information as a Global Resource

The growing importance of information in creating wealth is good news for countries less favored by geology and arable land than the early arrivers in the industrial age. The poor can get rich by brainwork—as first illustrated by the Japanese and more recently by the hustling, educated peoples of South Korea, Taiwan, and Singapore. These countries have not only grown faster than other developing nations, but they have spread the benefits of that growth more fairly among their people than other countries favored (as they are not) by oil, hard minerals, soil, or climate. Indeed, the striking paradox in the developing world is that the most successful countries are those least blessed with rich natural resources.

Even if the richer countries are not very good at helping the poorer ones—even if we act in Canutish ways by limiting access to our markets, trying to hoard our technologies, and starving our educational exchange programs—the developing countries that bet on universal education for their own people and seek out ideas about technology, management, markets, and governance can secure these hardest-to-hoard of resources.

By contrast, in the countries whose people have been kept in ignorance (by colonial policies, or their own leaders' mismanagement, or first one and then the other), it doesn't seem to matter what riches lie in the ground. Most of their citizens become the peasants of the global information society. The riches get siphoned off to the educated folk huddling in the affluent sections of their central cities—and to the information-wise foreigners who come in to do good and do well.

The excuse for poverty in the industrial era was that there weren't enough resources to go around. But if information, the increasingly dominant resource, is really expandable, diffusive, and shareable, there will be less opportunity in the future to deprive whole populations of the benefits of development. The modern King Canutes will be wise to assume that the information tide is coming in and adapt their behavior accordingly. Knowledge is power, and let's not forget it. □

Saving Energy: The Human Dimension

BY PAUL C. STERN

MANY people assume that energy is bought, sold, and used in a rational economic fashion. According to this theory, the profit motive encourages manufacturers to produce energy-conserving technologies that can save money, and energy users act in their own interests to put these technologies to work.

Of course, certain market "imperfections" are recognized. For example, owners of rental property have little incentive to make investments that would save only their tenants energy. Because buildings and to some extent other capital stock such as factories and farm equipment last a long time, energy efficiency cannot be improved overnight. The poor can rarely save or borrow enough to invest in conservation and in the long run end up paying for excessive amounts of energy.

Such barriers to conservation should not be minimized, but there are others that people easily overlook when they think of energy use as being governed by market forces. These barriers have to do with the way social forces and the psychology of individuals affect energy use.

Energy Invisibility

Physicists tell us that with the exception of a small part of the electromagnetic spectrum, energy is invisible. Energy is also psychologically invisible whenever people cannot see the connection between the actions they take and the energy they use as a result.

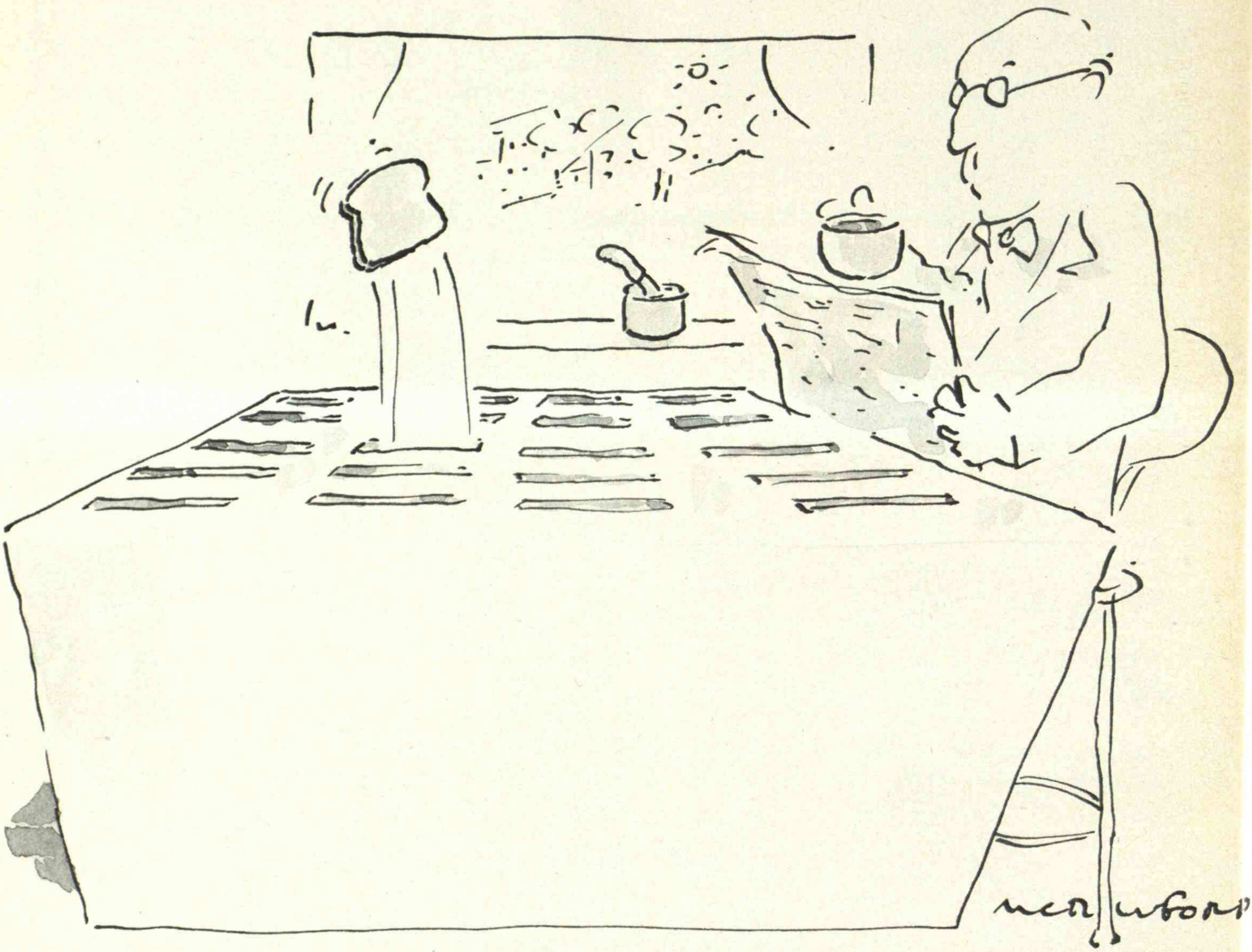
One of the clearest examples of this is provided by the residential electric bill. Imagine a supermarket where nothing you buy is marked with a price. The only price you see is the total at the bottom of the cash-reg-

This article is based on sections of a National Research Council/National Academy of Sciences report, "Energy Use: The Human Dimension," to be published by W. H. Freeman in March. The report develops a social-science perspective on energy policy. It explores how individual and social behavior affects energy conservation, preparedness for energy emergencies, and local groups' efforts to solve energy problems.

THERMOGRAM: DAEDALUS ENTERPRISES, INC.

People aren't always rational economic actors. What motivates the way we use energy, and how can conservation be encouraged?

Energy is usually invisible, both physically and psychologically, but this thermogram reveals the heat escaping from a row of houses in Plymouth, Mich. Infrared light (or heat) was mapped and transferred electronically onto film. White indicates the warmest areas where most heat is escaping; red, yellow, green, blue, magenta, and black form a descending scale of temperatures.



ister receipt, and that is given out only once a month. This is the plight of residential electricity users. They purchase lighting, hot water, the use of appliances, and space heating and cooling without any idea of how much each item costs. Lacking this vital information, householders tend to overestimate the amount of energy used by equipment that is visible and that must be turned on and off, such as lights and televisions. They tend to underestimate the energy used by invisible and unobtrusive equipment such as water heaters. Because insulation in walls or flame-retention oil burners (a recent development in energy-efficient heating equipment) cannot be readily seen, people often fail to think of them when they want to cut their home heating bills. In energy use, as in other matters, seeing is believing.

Building contractors have noticed this phenomenon. They report that it is easier to sell a home with solar collectors on the roof than one with features that may be much more cost-effective but less conspicuous, such as extra insulation or an orientation that allows solar heat to be absorbed in winter and kept out in summmer. Researchers have also found that energy use that is out of sight is out of mind. This was documented in a study by Willett Kempton, an anthropologist at the Institute for Family and Child Study at Michigan State University, and several colleagues. Householders in Michigan surveyed by Kempton believed that by turning off lights and televisions they could save more energy than experts say

ILLUSTRATIONS: MICHAEL CRAWFORD

Energy policies are associated with images of freedom and loss of freedom, control and loss of control.

these household technologies use in the first place. Furthermore, these people's misconceptions were hard to dispel. Many of the people in the study were given computerized energy audits recommending ways to save energy in their homes. Yet they still held many of the same incorrect notions about how to save energy as those who were not offered audits.

Such misconceptions have a pernicious effect on attempts to improve energy efficiency. Motivated by high prices, people try to save energy, but when they take ineffective actions and overlook effective ones, they are disappointed. As a result, some give up on conservation. Energy's invisibility also means that when people do take effective conservation measures, they cannot tell how much they have saved. This keeps these measures from earning the reputations they deserve.

The effect of energy invisibility can be estimated. Robin Winkler and Richard Winett, psychologists at the University of Western Australia and Virginia Polytechnic, examined a number of studies in which householders were given regular feedback on their energy use—a procedure that made it more visible. Of course, each of the studies was performed differently, but the feedback typically consisted of someone's arriving daily to give a meter reading of the amount of electricity or gas used. The readings were often adjusted to correct for changes in the weather, so they would more accurately reflect householders' actual energy-related actions. The householders were also sometimes told how much money they were spending on energy.

All these studies showed that making energy use visible does make a difference. For example, in a study by researchers at the Center for Energy and Environmental Studies at Princeton University, people paying $44 per month for gas for home heating were able to curtail their energy use by 6 percent with feedback. Furthermore, Winkler and Winett discovered that making energy use visible helps people conserve most effectively when their incentive is greatest—when they are paying a lot each month for energy for a given purpose. In a study conducted in Kentucky by Winett and one of his colleagues, people who were paying $130 per month for electricity for heating were able to curtail their use by 15 percent with feedback. Thus, as energy costs rise, the costs of energy's invisibility increase even faster—both for the individual householder and for the nation.

The studies showed that householders often save 15 percent on energy in the short run when given feedback on energy consumption. Feedback can also lead to savings in the long term by helping people see the effectiveness of efficient equipment. Thus, the total savings from providing feedback on energy use—or the total energy lost because of its invisibility—may be more than 20 percent.

Confusing Information

A common assumption is that consumers provided information about the costs and benefits of energy efficiency will take rational economic action. Unfortunately, this assumption has major loopholes. To begin with, the ultimate payoff of energy savings is highly uncertain—even experts cannot forecast energy prices very closely. It is easier to gauge how much energy will actually be saved by any given conservation measure—if energy users are willing to sift through and evaluate enough information. But doing this is difficult, and few people have the time. Having a single credible, expert source of information on energy conservation could solve this problem, but instead, most people hear a lot about energy use that they simply do not believe.

There are good reasons for people's skepticism. One has to do with the limitations of general advice about energy. People may hear, for example, that it is useful to insulate basements—but that is much more true when the basement is above ground level. What saves energy for some is wasted effort for others. Wasted effort leads to disappointment, and when transmitted to neighbors and friends, this creates general skepticism.

Credibility also suffers because of conflicting advice. Gas, oil, and electricity suppliers give information that favors use of the fuels they sell. Furnace suppliers tend to give information on how to save energy with furnace technology but not in other ways. Government tells the public that conservation is imperative, but government also tells people that the way to solve the national energy problem is to build new pipelines, raise prices, or develop synthetic fuels. Furthermore, although some government agencies do offer good advice on conservation, other agencies respond to political pressures. For example, the Carter administration concluded that rail transportation is more energy efficient than automobile transportation, but when the Reagan administration came to power, it asserted the opposite. In short,

Energy auditors are not only technicians but communicators, and too often they fail in the latter role.

there are good reasons for public skepticism, and because experts will continue to present different sides of important energy questions, conflict and confusion will persist. In this environment, simply producing accurate information and disseminating it may have no effect at all.

The key is that the information be credible. Samuel Craig and John McCann, marketing professors at Cornell University, showed that some sources are more credible than others. They sent pamphlets to households with air conditioners telling how to save energy in keeping homes cool. Half the households received a cover letter on the letterhead of the local electric utility; the others got the same letter from the state Public Service Commission. The people who thought the information came from the state agency saved a small but observable amount of electricity over the next month—about 7 percent of their bills. The others saved none. The point is not that state agencies are generally trustworthy, or even generally more trustworthy than utilities. The point is that energy programs should be designed so people will get information from a source they are likely to trust.

The Symbolism of Energy

Much policy discussion has symbolic meaning, and energy policies, in particular, are associated with images of freedom and loss of freedom, control and loss of control. President Nixon's call for "energy independence" meant that by producing more energy, the nation would enhance its power and control. President Carter's declaration of "the moral equivalent of war" implied that turning down the thermostat was a sacrifice involving loss of control, albeit for the national good. One recent study of energy conservation, titled "Our Energy: Regaining Control," suggests that by improving energy efficiency it is possible to regain control from distant energy suppliers.

These symbols can have powerful effects. Americans are more likely to take actions they see as increasing their control over their environment than to do things they equate with giving up control. A number of studies have documented this point. For example, in 1975 the army tried an experiment to reduce fuel consumption in vehicles by installing a device to stop drivers from accelerating cars or trucks too rapidly. The drivers soundly opposed this gadget, and about 10 percent simply disconnected it. Researchers at the Center for Energy and Environmental Studies at Princeton University used the opposite tactic to overcome people's resistance to thermostats that automatically turn down the temperature at night. The researchers had such day-night thermostats redesigned so residents could override the system temporarily. Because they were given added control, the residents found the redesigned thermostats much more attractive. Other studies have arrived at similar results outside of the field of energy.

This suggests that it is counterproductive for politicians to equate conservation and sacrifice. The rhetoric can be changed and energy policies can tie efficiency to an increase in control. When people are forced to undertake conservation in a crisis by cutting back on amenities, they experience a loss of control. When they save energy under the slower pressure of steadily rising prices, and when policies help them obtain energy-efficient equipment, people are likely to feel that they are gaining control.

Picturing Energy Users

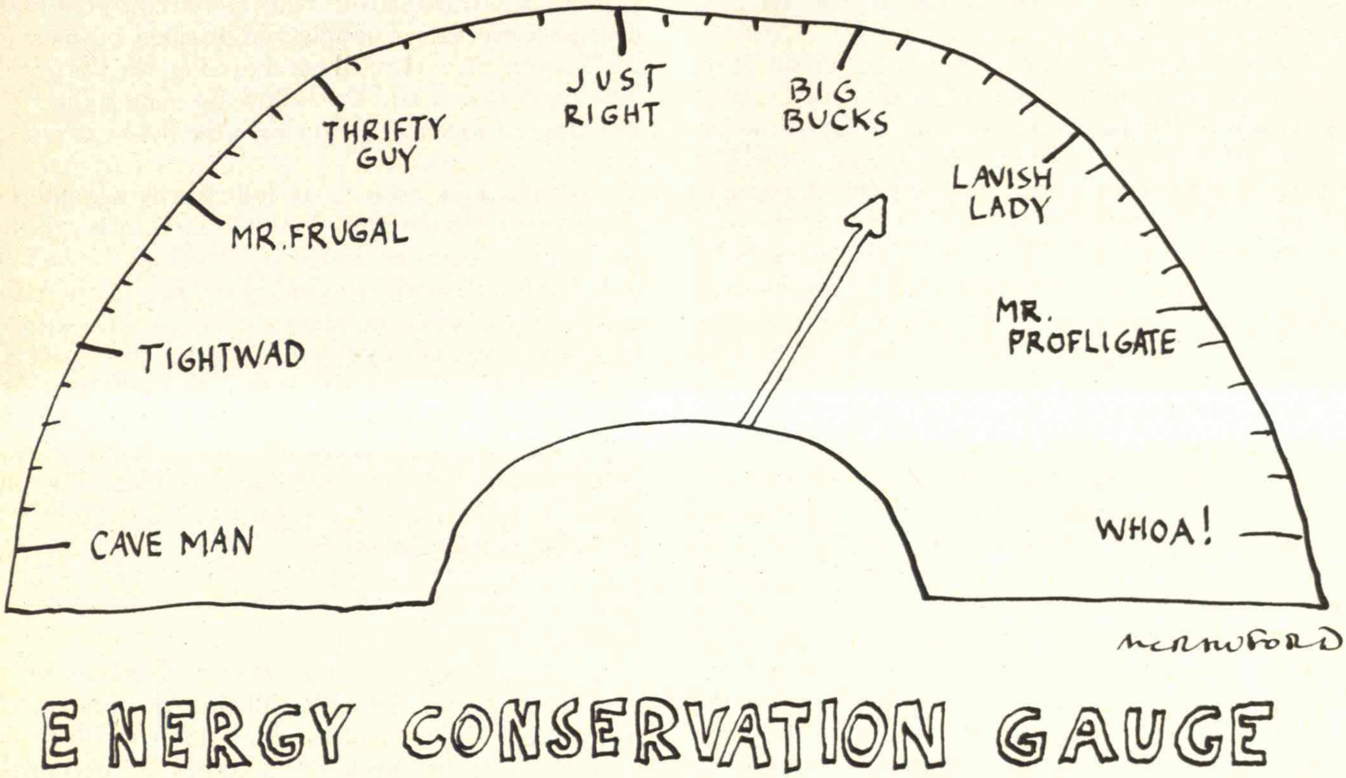
Just because energy users are not always rational economic actors does not mean that they are irrational. Their behavior makes sense, but not necessarily in economic terms. In picturing the energy user, one should keep at least five images in mind:

☐ *The investor.* This is the familiar view of energy users as economically rational. But they frequently do not act this way, even when they are trying to promote their own interests. First, householders usually quantify their energy use in terms of dollars rather than energy units, and they often do not correct these dollars for inflation. As a result, they fail to notice energy savings when rising prices keep their total bills from dropping. Thus, someone who tries to be economically rational but fails to take rate increases and inflation into account will not make some investments that an economist would consider justified. The more fuel prices escalate and the longer the payback period of a potential investment, the greater this problem is.

The second problem with the notion of energy users as investors is that they may think of investments in energy-consuming equipment primarily as necessary repairs. For example, if a service person says the water heater needs replacing, the homeowner simply agrees to install a new one, ignoring its effect on the energy bill over the next 15 years.

There is a third flaw, mentioned earlier, with the

Since people are justifiably skeptical of much that they hear about energy, simply providing accurate information about conservation may have no effect at all.



notion of the energy user as a rational investor. This occurs when the investor is not in fact the user but an intermediary such as an owner of rental property or a developer. An investment in energy conservation does not save the intermediary any energy, although the intermediary may benefit indirectly if the sale price of a home increases or it is easier to rent an energy-efficient office building.

□ *The consumer.* Energy users sometimes think of their homes, automobiles, or other property as providing amenities or aesthetic value, rather than as being long-term investments. Thus, home-improvement loans are taken out much more frequently for room additions or new siding than for insulation or improved furnaces. Among energy conservation investments, the usual preference for storm windows over wall insulation may reflect the same phenomenon. Storm windows are attractive and reduce the amount of upkeep needed; insulation offers a faster return on the investment but lacks these consumer benefits.

□ *The group member.* Energy users are sometimes influenced by what their friends think. The more uncertainty that exists about energy, the stronger these social influences tend to become. If a utility energy audit recommends wall insulation, but a neighbor says it didn't save her money, many people will take the neighbor's advice and do nothing.

Social influence can also mobilize people in collective efforts. For example, in 1979 the city of Fitchburg, Mass., undertook a six-week energy-efficiency drive using a small grant from the U.S. ACTION program. Low-cost energy conservation kits and information on how to use them were provided at centers set up in local storefronts, and groups of people attended demonstrations at these centers, workplaces, and people's homes. Over half the households and many of the businesses in the city became involved in the effort, a lot of devices were installed, and energy savings were estimated at 14 percent.

□ *The committed individual.* People are sometimes motivated to save energy because of their values and habits rather than from economic incentives. This is especially true when it comes to taking inexpensive and easy actions. For example, when electric rates are lowest at nights and on weekends, people's individual

If government policies rely on economics alone, energy efficiency will remain far short of what is economically justified.

commitment can have more effect on whether they use appliances at these times than the actual price difference.

This was documented by Thomas Heberlein of the Department of Rural Sociology at the University of Wisconsin at Madison and Keith Warriner of the Department of Sociology and Anthropology at the University of British Columbia. They selected a group of people and used a questionnaire to evaluate their commitment to conservation. Different households were given night and weekend electric rates one-half, one-quarter, or one-eighth as great as the day rates. The level of commitment had more effect than the size of the discount in determining who switched electricity use to low-rate times.

Personal commitments can change; even seemingly minor steps can create momentum. For example, in 1979 the U.S. Department of Energy sent information to every household in New England on free and low-cost energy-saving measures for the home. Enclosed with each pamphlet was a plastic flow restrictor for the shower. New England households installed more flow restrictors that year—and went on to take more of the other energy-saving measures listed in the pamphlet—than a comparison group. A campaign consisting mainly of written information is rarely so successful. Apparently, the energy-saving device stimulated people to begin the program, and the influence of that first step encouraged them to continue. This "foot-in-the-door" phenomenon has been well established by social psychologists.

□ *The problem avoider.* People sometimes wait for a crisis to come: they do nothing until the furnace breaks or prices jump drastically. Then they tend to simplify decisions, relying on rules of thumb, habit, or one trusted source of advice. The most important thing a conservation program can do to reach people who act this way is to make improving energy efficiency simple.

An example of this was provided by a conservation program in the state of Rhode Island known as RISE (Rhode Islanders Saving Energy) that I studied with several colleagues when I was at the Institution for Social and Policy Studies at Yale University. A nonprofit organization receiving part of its money from utilities, RISE provided a one-stop conservation service. Its auditors would assess the energy needs of any house in the state free. The organization provided access to low-interest loans, a list of approved contractors, and inspections after the work was done. The most attractive features of the program that people mentioned in our study were those that made energy conservation simple and avoided problems—the convenience of one-stop shopping, the list of reliable contractors, and the follow-up inspections. The low-interest loans were far down the list of attractive features.

Organizations as well as individuals use energy, and though it is tempting to think of them as rational economic actors, they too have a "human" side. Like individuals, they copy peers and are greatly influenced by personal communications. Like individuals, they follow standard procedures rather than calculating the expected value of every action. Problems go unaddressed unless they can command the scarce attention of important decision makers. And like individuals, organizations are problem avoiders. They are typically willing give up some chance of profit to avoid unpleasant surprises.

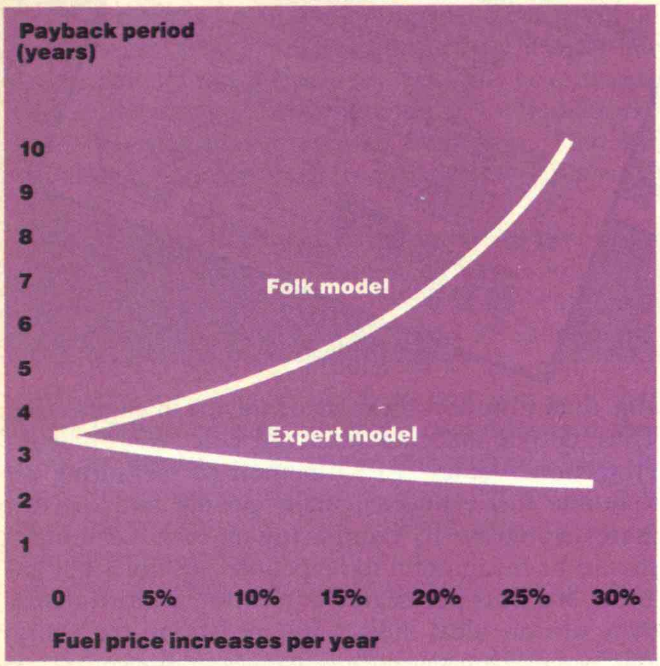
What to Do

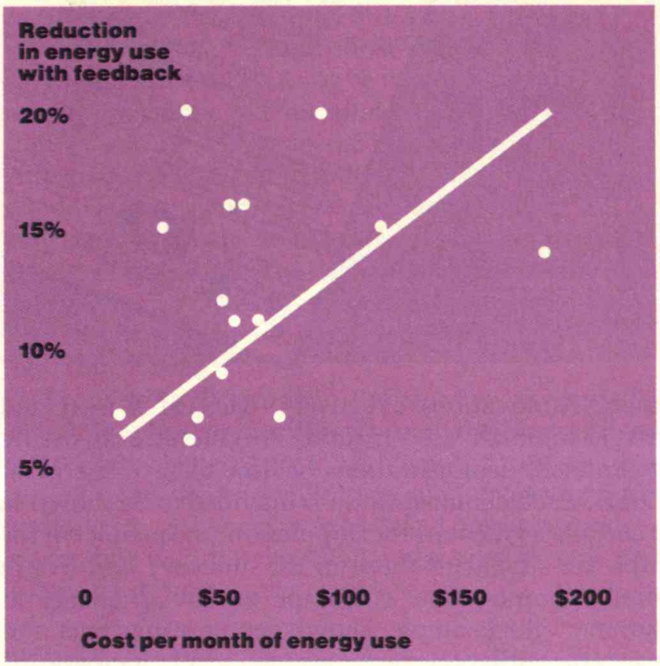
How can policymakers use these perceptions to reduce energy use? Though enlisting the human dimension in saving energy does not substitute for long-term technological advances or economic incentives, it can be more cost-effective in the short run. However, such an effort requires government to play an unfamiliar role. Prevailing attitudes that restrict the government role in conservation policy to offering economic incentives, funding technological research, and distributing pamphlets are, in a sense, yet another barrier to energy efficiency.

Clearly, with the exception of nuclear power, the Reagan administration prefers to treat energy as an ordinary market commodity. Even past administrations have not seriously established national programs to address energy efficiency. A comparison with Canadian energy policy makes this clear. In the late 1970s the Canadian government ran full-page advertisements in daily newspapers promoting home insulation and energy-efficient automobiles. One advertisement shows a woman who saved 178 gallons of oil by insulating her house saying, "Better that the money be in my pocket than the oil company's." Another ad provides a fuel-economy guide to all new cars on the market. The most fuel-efficient cars are labeled as "part of the solution" and the least fuel-efficient—the majority of the models—as "part of the problem."

When energy prices rise, an investment in conservation pays for itself in a shorter time, as the "expert model" shows. But ironically, because of rising prices, actual energy bills don't drop, so householders often fail to notice the savings. Their "folk model" sees not a shorter payback period but a longer one.

A number of studies have given householders feedback on energy consumption—daily reminders of how much they are using. The more people pay for energy, the larger the percentage they tend to conserve when given feedback. Each dot represents the conservation achieved in a particular study; the line shows average savings. (Diagram courtesy of *Energy*, Pergamon Press, Ltd.)





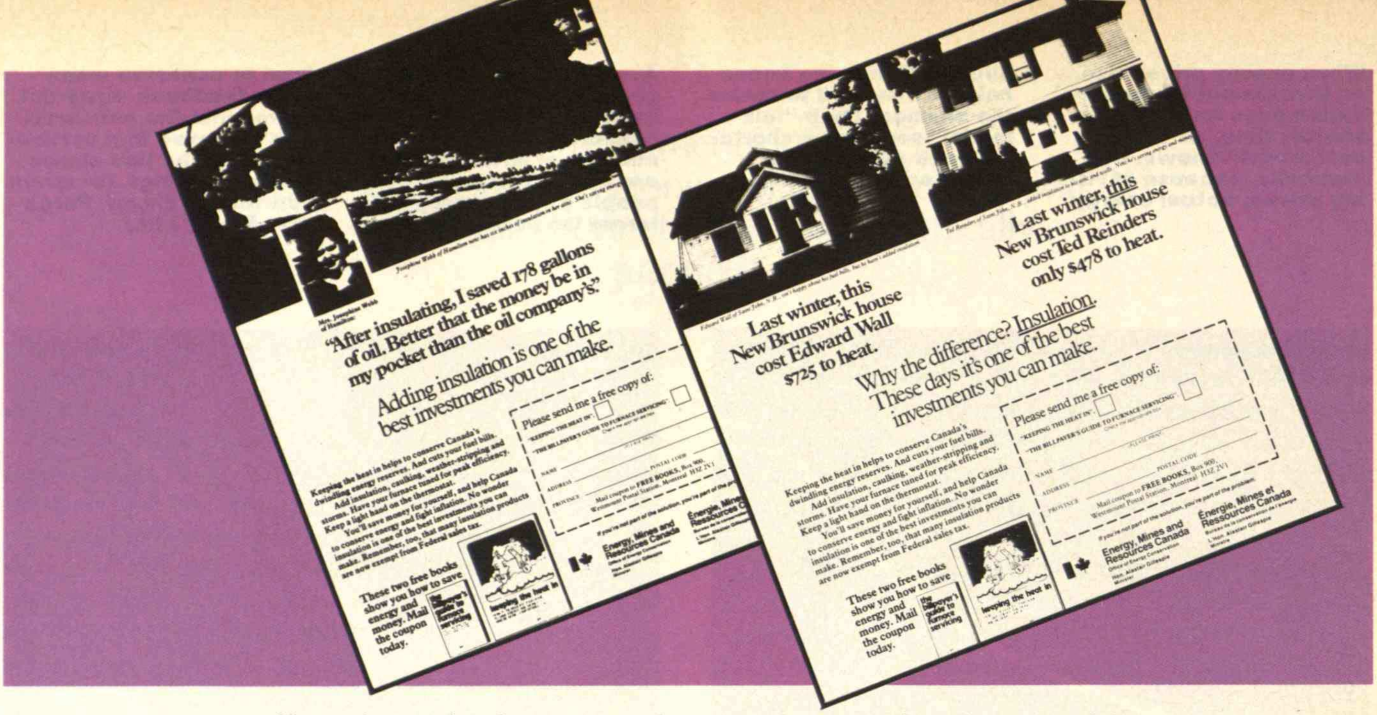
Paying for media advertising and taking on the oil and automobile industries in the Canadian fashion are unthinkable for our government. This timid attitude keeps it from communicating energy information in the most effective ways. This will change only if the U.S. public or its federal, state, or local governments decide that there is a serious public interest in promoting energy efficiency. Those in the public sector who see such an interest, and those in the private sector who have such an interest, should consider these recommendations:

□ *Communicating effectively*. Although the Canadian government used mass-media advertising to promote energy efficiency, and U.S. utility companies now spend many millions on such advertising, this is often not the most effective approach. Advertising a brand of toothpaste may make sense, because consumers are sure to choose some toothpaste, and the advertiser seeks only to influence which brand they choose. Thus, the Canadian government ad recommending fuel-efficient cars might be effective. But promoting energy efficiency usually requires encouraging new behavior—rather like selling toothpaste to people who have never brushed their teeth. Research has been done on the introduction of high-yielding seed varieties, the shopping cart, and other innovations. Word-of-mouth communication about a new product or practice, direct experience using it, and the testimony of others who have used it have proved to be much more effective than less personal mass-media advertising.

This suggests that money spent on advertising could be used more effectively to demonstrate energy conservation concretely. Funds might be given to community groups to undertake energy conservation projects that would be seen by many people. Several energy conservation programs, including the ACTION program in Fitchburg and one carried out by Seattle City Light, have reported success with approaches that rely on word of mouth. The Fitchburg program provided workshops showing people how to weatherstrip, make aluminum-foil heat reflectors for radiators, or use a $20 energy conservation kit. Seattle City Light sponsored so-called "Tupperware party" demonstrations: nothing was actually sold, but about a dozen families would gather in a neighbor's house with a representative of the utility for a hands-on demonstration of ways to save energy.

These direct approaches to promoting conservation encourage small initial commitments that people may continue to build on. They make energy conservation concrete, vivid, and understandable. They enlist the strengths of credible local institutions, and they create networks of social support for energy conservation.

Even cable television can be adapted to spread



energy innovations effectively. Richard Winett and his associates at Virginia Polytechnic Institute videotaped demonstrations of how to save energy at home. Each demonstration is intended to be shown to a certain segment of the population; the people on the tape are similar to those in the audience and live in similar homes. One videotape on saving energy in summer, for example, shows people using fans and natural ventilation in the evening, and changing the time and place of cooking, to reduce the need for air conditioning. In initial trials in Salem, Va., these tapes led people to save 15 to 20 percent of household energy. No new equipment, except perhaps some fans, was required. Overall changes in indoor temperature were negligible, and the residents did not sacrifice comfort.

□ *Making energy visible.* As mentioned, feedback provides information that is relevant to an energy user's own situation, and it can enhance the credibility of claims that insulation or other invisible improvements save energy. Simple devices could provide feedback by measuring energy use, whether of electricity, gas, or oil. They can be designed to correct for weather and other extraneous factors. These devices could provide figures daily, and might also supply comparisons with the past. Thus, householders could see how insulation, weatherstripping, and other measures paid off. People could tell whether predictions of energy conservation proved true and if so how much money they saved.

Utilities could even provide some feedback by sending customers bills that show energy use corrected for weather. Attempts to do this have had mixed results, but the approach could be a valuable part of a conservation program in places where the utility is a trusted source of information.

□ *Stating energy use simply.* It is sometimes more important for energy information to be understandable than to reflect the state of the art in engineering. Thus, despite inaccuracies in the U.S. Environmental Protection Agency (EPA) method of measuring automobile fuel economy, many people find the estimates valuable in comparing models. An index should be meaningful to laypeople—as miles per gallon is but Btus per degree-day is not. Unfortunately, there are no ideal indices for measuring the energy efficiency of houses and appliances. However, promising ones are emerging and could be improved.

For example, the government has developed energy-efficiency ratings for air conditioners, and stickers giving annual estimated costs must be attached to new refrigerators and some other appliances. These indices should be tested to see which ones people find useful. Systems have also been developed for rating the energy-efficiency of buildings. The Department of Energy is developing a system that rates the energy efficiency of homes on a scale from 0 to 10. Some utilities such as Georgia Power in Atlanta will certify homes that meet their energy conservation standards. These rating systems for homes are also worthy of careful testing and might be improved.

□ *Doing energy audits convincingly.* Energy auditors are not only technicians but communicators, and too often they fail in the latter role. Vivid images are much more compelling than compilations of data. Thus, instead of telling a homeowner to weatherstrip the front door, the auditor might use a smoke stick that emits a fine powder to show how warm air from the house escapes under the door. Instead of simply stating that a homeowner can save 20 percent of heating costs by taking a series of conservation measures, the auditor might name a family in the area that has actually made the savings.

Unfortunately, quite the opposite approach has gained favor recently. In all states energy audits are

The Canadian government is concerned enough about energy conservation to advertise its benefits, even if that means taking on the oil companies. The intent is laudable, but advertising may not be the best way to introduce unfamiliar technologies. Research suggests that concrete demonstrations in communities—analogous to those performed by agricultural extension stations—are far more effective.

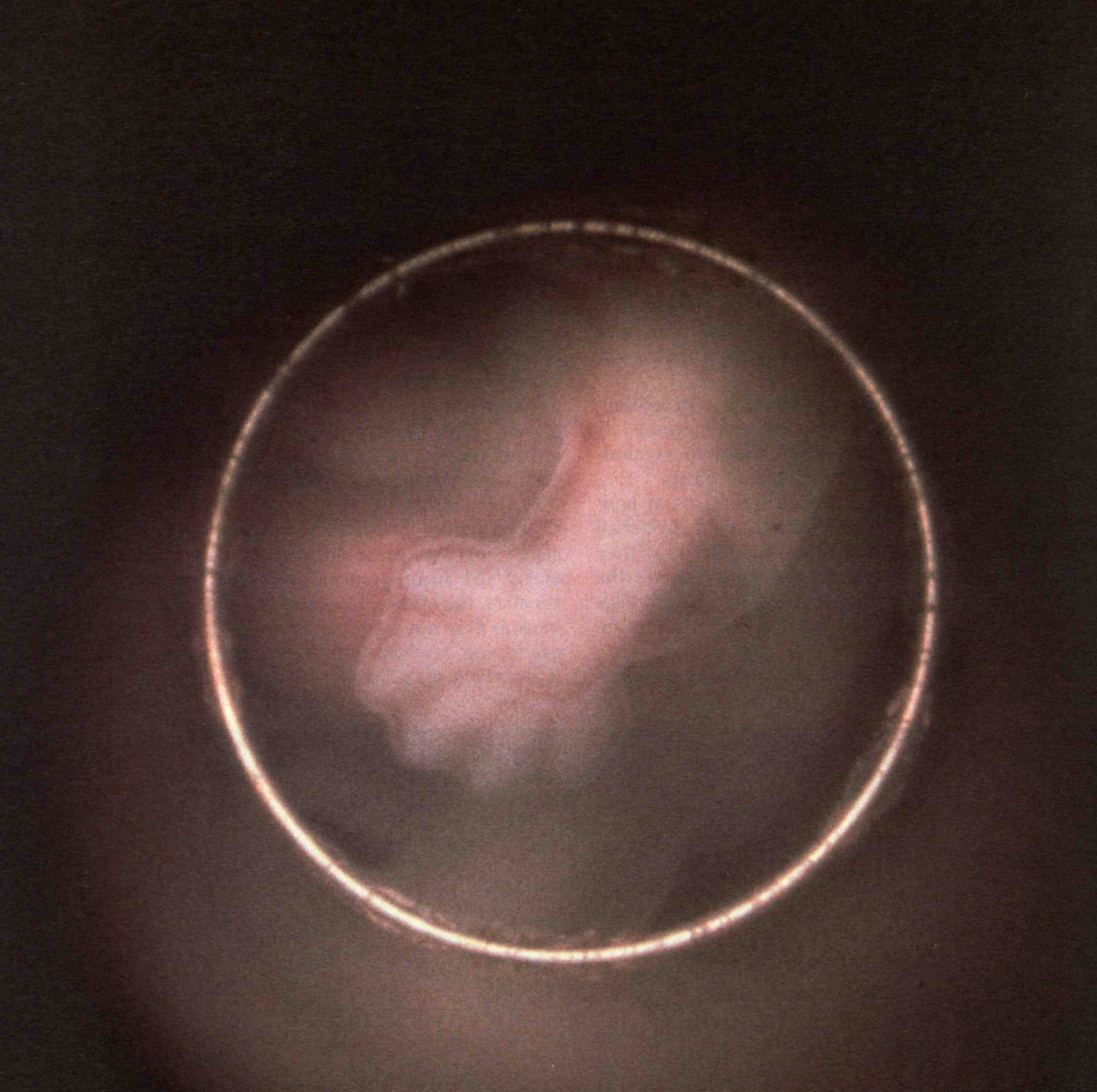
performed for a small fee by Residential Conservation Services, which were established by federal law but are usually run by local utilities. The government recently decided to allow these audits to be delivered by mail rather than presented in person. This will probably cost much more in energy than it saves in labor.

Auditors should consider alternatives to describing energy conservation as a way to save money, as Suzanne Yates found in her Ph.D. thesis in psychology at the University of California at Santa Cruz. Homeowners were less influenced by claims of how much insulating their water heaters would save than by predictions of how much they would *lose* if they failed to insulate. (Of course, the numbers are the same, but people's reactions seem to depend on how they are presented.) This finding appears to be broadly applicable.

Energy auditors can create or stifle energy users' commitment. For example, it does not make sense to insist that people take the most cost-effective conservation measure first. Even if it is less cost-effective, something simple like installing a flow restrictor in a shower can be a foot in the door leading to energy efficiency. When demonstrating how to weatherstrip windows or insulate electrical outlets, an auditor can ask homeowners to do one or two installations themselves. This hands-on experience both creates a commitment and increases people's sense of control—people sense that energy use is something they can master.

□ *Preventing headaches.* Improving energy efficiency involves great difficulties at the outset. Especially for homeowners and small-business proprietors, the effort of collecting and evaluating information may not seem worthwhile. Conservation programs can help by simplifying the process and pro-

(Continued on p. 62)



By inserting a slender, glass-and-steel tube into the cervix, doctors can observe how a human embryo grows. At one end of the tube, called a fetoscope, is a miniature lens that peers through a transparent "window" in the amniotic sac and captures images of the fetus. These light images travel up the fiber-optic tube to a sharp focus at the other end.

Seen here is the outstretched arm of a five-week-old fetus.

PHOTOGRAPH: ALEXANDER TSIARAS

Healing Before Birth: An Ethical Dilemma

BY JOHN C. FLETCHER

Fetal therapy may eventually be used to save thousands of children from lives of suffering. But most fetal procedures are still risky and experimental, and the ethical questions they raise are troubling.

FETAL therapy is in the news, but the wrong messages are being sent. Last April, for instance, *Life* magazine announced "Surgical Miracles inside the Womb" on the cover of an issue with a story on fetal surgery. The story told of a fetus who was hydrocephalic—excessive fluid had built up in the brain, crushing normal developing cells. Hydrocephalus often results in retardation, blindness, or death. But in this case, physicians were able to drain the fluid by a shunt placed through the skull during the fifth month of pregnancy. The child, now two years old, wears a permanent shunt that continues to drain fluid, and he appears normal. Another account in the same article told how a 21-week-old fetus was briefly removed from the womb for corrective surgery on malformed ureters, the ducts by which urine passes from kidney to bladder. This fetus was later delivered without complications. Unfortunately, the baby died soon after birth because of lung damage before surgery.

A "miracle" is generally understood to be an event marked by divine intervention in human affairs. In reality, fetal therapy falls far short of miracles, especially for those who work in the field. The work is risky and requires an assembly of experts difficult to organize except in hospitals with the most advanced equipment, obstetrical services, and intensive-care nurseries for newborns.

The advent of fetal therapy also raises some disturbing ethical issues. Questions such as which fetuses can best be helped by fetal therapy, and what should be done if a mother refuses a proven treatment, must be resolved before fetal therapy becomes widely accepted. In the long run, physicians and policymakers will also have to consider other issues: Is fetal therapy worth the costs? Will the correction of fetal disorders simply preserve more genetic defects in the population and add to the burden of suffering? Debate on these important issues should begin now—while fetal therapy is still in its infancy.

Advances in ultrasound have provided a steadily widening window through which to treat problems before birth.

The Early Results

Fetal therapy is not new. Since Dr. William Liley of New Zealand first succeeded in giving blood transfusions to fetuses in the 1960s, thousands of infants have been successfully treated in utero for Rh disease. (The complications in Rh disease stem from the incompatibility of blood factors between the mother and fetus.) Further advances have been slow, and only recently have physicians begun to experiment with more radical approaches to fetal therapy.

Advances in ultrasound examinations are the main reason that fetal therapy is more possible now. Physicians who specialize in ultrasound imaging can identify abnormalities in the fetal head and large pockets of obstructed urine in the body, among many other anatomical factors. The risks from exposure to ultrasound's radiant energy are believed by most obstetricians and radiologists to be nil, but no long-term studies of the possible effects have been done. Meanwhile, ultrasound and the fetoscope, a thin fiber-optic tube that is inserted into the pregnant uterus for viewing the fetus, provide steadily widening windows through which to treat problems before birth.

Most of the physicians who perform fetal surgery in North America and the United Kingdom cooperate in maintaining the International Fetal Surgery Registry. According to the registry, which is kept by Dr. Frank A. Manning at the University of Manitoba, surgery has been performed on 25 fetuses with congenital hydrocephalus, with 21 infants surviving (84 percent). Three of the four deaths resulted from associated malformations; only one resulted from surgery. However, these survival statistics are far more impressive than the progress of the infants. Only nine were felt to be "normal" 1 to 18 months after birth. Three have "moderate handicaps" and another nine have "severe handicaps."

Of 35 fetuses reportedly treated for congenital hydronephrosis, or malformations of the urinary tract, only 14 survived (40 percent). However, the future of these surviving infants looks much brighter than the prognosis for those treated for hydrocephalus. Of the 14 infants who survived, 13 have normal kidney function and apparently no severe or moderate handicaps. These infants have been observed from as little as one month to as long as two and a half years. Of the 21 infants who died, the main cause of death was severe damage to lung tissue and failure of the lung to grow. In Manning's view, treatment before 20 weeks would have saved some of the nonsurvivors before lung damage had become too severe. (The vast majority of attempts at fetal surgery have occurred close to the thirtieth week. After 32 weeks, doctors prefer to wait for delivery.)

These results hardly approach the level of the miraculous. Except for a few cases that were clearly disasters before treatment, most cases of survival cannot be attributed to surgery. Until many more cases have been treated, it will be difficult to establish scientifically that performing fetal surgery is more beneficial then waiting until after birth to treat a disorder.

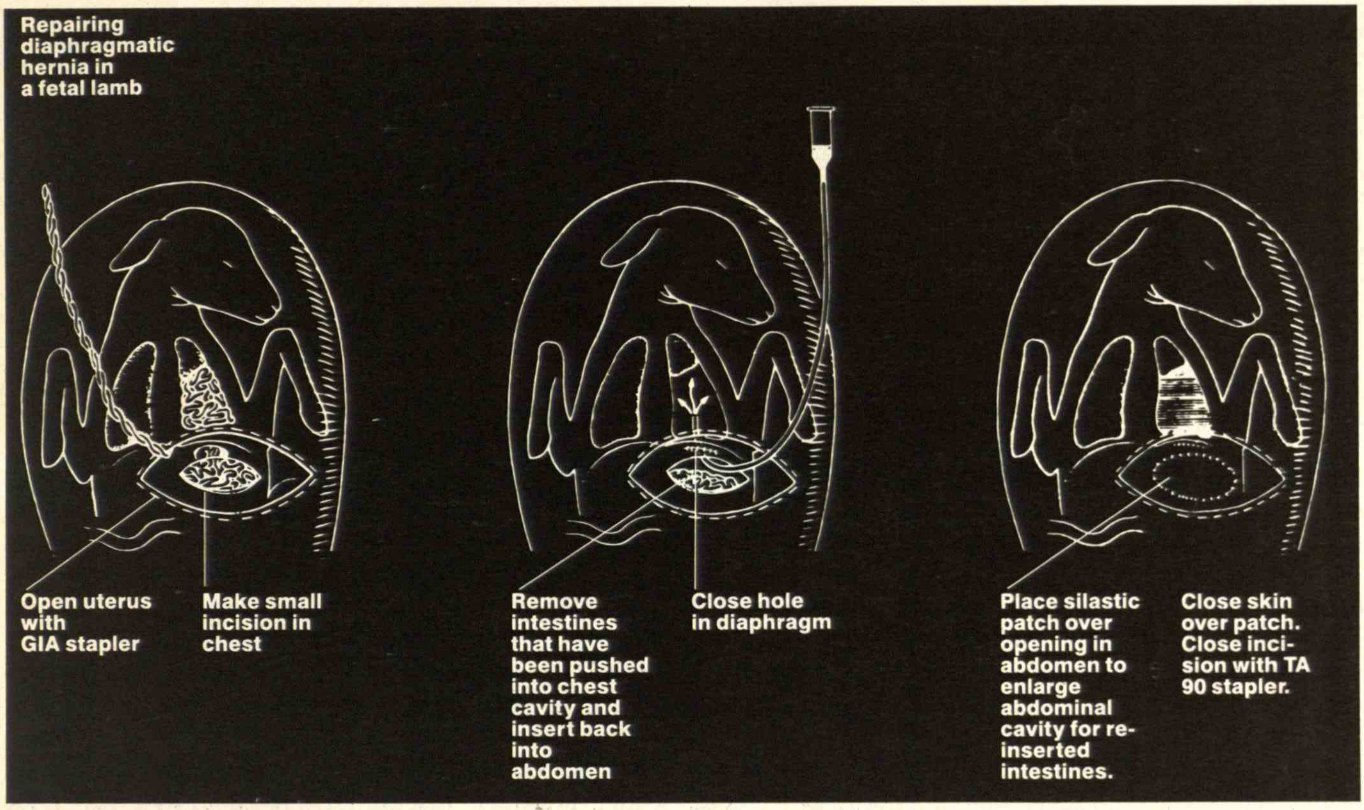
What Lies Ahead

The next goal of fetal surgery may be to correct a hernia, or opening in the diaphragm, that separates the thoracic and abdomenal areas of the body. Infants with a diaphragmatic hernia have a high death rate because their intestines and other organs have pushed through the hernia into the chest cavity, inhibiting lung growth. Researchers at the University of California at San Francisco (UCSF) have learned how to fix these hernias surgically in the uteri of sheep. But no one has yet attempted to repair such a hernia in a human fetus, in part because of uncertainty about what causes the lung disease from which these infants die. Some researchers believe that the lung damage may result from a cause other than the hernia, so repairing it may not entirely correct the problem.

In the future, fetal surgery may also be able to correct neural-tube defects (NTDs). In this disorder, the neural tube fails to close and the spinal cord and nerve bundles protrude through the back or head. Researchers at the National Institutes of Health (NIH) are developing methods for surgically treating fetuses with encephaloceles, a neural-tube defect in which a portion of the brain protrudes through the skull, and spina bifida, in which the protrusion is through the back. However, much more work must be done before these techniques, which have so far been tried on monkeys, can be applied to human fetuses.

At present, the main approach to uncovering neural-tube defects is to test the mother's blood for abnormally high contents of alpha-fetoprotein (AFP), a product of the fetal liver. When the neural tube re-

One immediate goal of fetal surgery is to correct a hernia, or opening in the diaphragm. Infants with such hernias have a high death rate because their intestines and other organs push through the hernia into the chest cavity. Researchers at University of California, San Francisco, have learned how to fix such hernias in the uteri of sheep. This three-step procedure involves putting the intestines back into the abdomen and closing the hole. It has not been applied to human fetuses.



mains open, AFP leaks into the mother's circulatory system. If the blood test, usually given in the fourth month of pregnancy, detects a higher level of AFP than normal, other tests should follow. Ultrasound is used to rule out twins, the death of the fetus, or other reasons for a high AFP level. Amniocentesis, a needle puncture of the uterus used to obtain fetal cells for study, is the definitive way to diagnose an NTD. Parents of a fetus with an NTD can choose to have an abortion or wait until delivery to begin treatment.

After birth, the standard ways of treating encephaloceles is surgically to remove the protruding brain tissue and close the skull. However, because part of the protruding brain includes the visual cortex, babies with encephaloceles are usually blind and often mentally retarded.

NIH researchers have been able to induce encephaloceles in monkey fetuses by giving the mother a synthetic corticosteroid. To heal the fetus, they open the uterus during the second trimester, partially remove the fetus, and cut off the protruding brain. They then seal the skull with bone paste—a mixture of ground fetal bones and culture medium—and return the fetus to the womb. Newly developed drugs are used to relax the uterus and prevent spontaneous abortions. After surgery, the brains of the monkey fetuses seem to regenerate in utero and the monkeys are born fully able to see.

The standard treatment for spina bifida after birth involves surgery to close the open spine and a shunt to drain excessive fluid from the brain. In the animal experiments at NIH, researchers are attempting to close the opening of the spine in utero with bone paste. Results suggest that monkey fetuses so treated fare much more favorably than those who have not been treated. However, there is a great difference between an experimentally induced NTD in a monkey and an actual malformation in a human fetus. Researchers are not yet sure whether prenatal surgery would help prevent the most serious consequences of spina bifida: paralysis and mental retardation.

The Medical Approach

Treating the fetus with medicine is another, less invasive approach to fetal therapy. Some lives can be saved or greatly improved by providing drugs or substances that the fetus lacks. Vitamins can now be

ILLUSTRATION: MICHAEL HARRISON, UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

So far the results of fetal surgery hardly approach the level of the miraculous.

given via the mother to correct serious deficiencies such as methylmalonic aciduria—an inability to break down carbon products—which results in death if the infant is not treated. Vitamin B12, given in large doses to the mother prenatally, has in some cases saved a child's life. Drugs can correct arrhythmias, or irregularities in a fetus' heart. Such treatments will probably far outstrip the potential for surgical correction, primarily because surgery is more irreversible and invasive. It carries more risk for both mother and fetus.

The first case of fetal therapy at NIH involved giving a drug to a 32-year-old mother to try to prevent the consequences of a serious genetic disease—21-hydroxylase deficiency—in the fetus. Also known as congenital adrenal hyperplasia, the disorder is caused by an inherited enzyme deficiency that results in the overproduction of androgens (masculinizing hormones) by the adrenal glands. So much androgen is secreted that female fetuses may have genitals that resemble those of males. In this particular case, the woman, who was eight weeks pregnant, had a mild form of the disorder. She also had a five-year-old daughter with a severe form of the disease that had been corrected by surgery. The parents had decided that if amniocentesis, which could not be perfomed until the sixteenth week, showed another affected female fetus (based on elevated hormonal levels), they would choose abortion over bearing a second child with the problem. Physicians at the National Institute of Child Health and Human Development (NICHD) offered to try an experimental therapy of daily doses of a steroid called dexamethasone. The doctors believed that the steroid would pass through the placenta, suppress the fetal adrenal glands that produced the androgens, and perhaps prevent the formation of malelike genitals if the fetus were an affected female. Geneticists calculated that the odds of giving birth to a second affected female were between 1 in 4 and 1 in 8.

What were the risks? The steroids had caused malformations such as cleft palate in the offspring of animals, but the animals were given excessively large doses. On the other hand, many pregnant women with diseases treatable by steroids (such as Crohn's disease, an inflammation of the bowel, and lupus) had been treated without harm to the fetus. An amniocentesis performed at 17 weeks would determine the sex of the fetus; if it was male, the treatment would be tapered immediately to avoid the slightest risk of a birth defect. The physicians also hoped a study of fetal cells gathered by amniocentesis would determine whether the fetus had a genetic predisposition to the disorder.

Treatment began while the fetus was between 10 and 14 weeks of age. Regular urine tests showed that its adrenal gland was definitely suppressed. A few weeks later, amniocentesis showed that the fetus was female but proved inconclusive in determining any genetic predisposition to the disorder. So treatment continued, and a healthy female was born with no complications. Postnatal testing showed that, like her father, the baby is a carrier for the disorder, but genetically she would not be expected to have even a mild expression of the disease. Thus, although treatment was unnecessary, the experiment did show that the drugs can indeed suppress production of excessive androgens by the fetal adrenal gland. Another trial of the therapy is now underway in France, but no results have been reported yet.

On the most distant horizon of fetal therapy, doctors may one day be able to insert healthy genetic material (DNA) into a fetus to replace faulty genes inherited from parents. In experiments with mice and other animals, researchers at the NIH, the Oak Ridge National Labortories, Jackson Laboratories, and the University of Pennsylvania are attempting to learn how to direct "good" genes to the target cells, and how to keep them there without harming other cells. They have bred a species of mouse that has a disease similar to beta-thalassemia in humans, a disorder that destroys red blood cells. The hope is to replace DNA in the mouse embryo so that its offspring inherit the healthy new genetic information. If such gene therapy works and no harm comes to the offspring, it may be possible to try something similar in humans. But long before this type of gene therapy becomes possible, donors may be able to give bone-marrow cells to children afflicted with these blood diseases, in the hope that the new cells would multiply and overwhelm the defective cells.

The Ethical Questions

Even though fetal therapy is still experimental, it is not too soon to begin discussing some obvious ethical implications. Fortunately, many of the physicians in this field have recognized the need for debate. At two recent meetings, one sponsored by the Kroc Foundation (Ray Kroc owns the McDonald's chain)

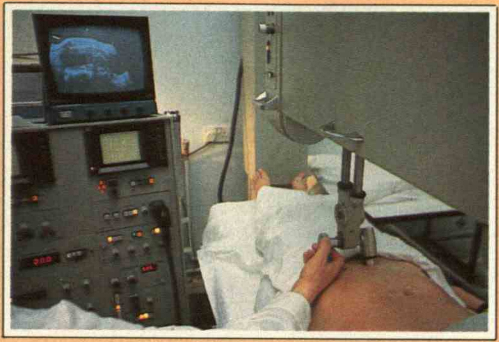
A Head Start on Birth Defects

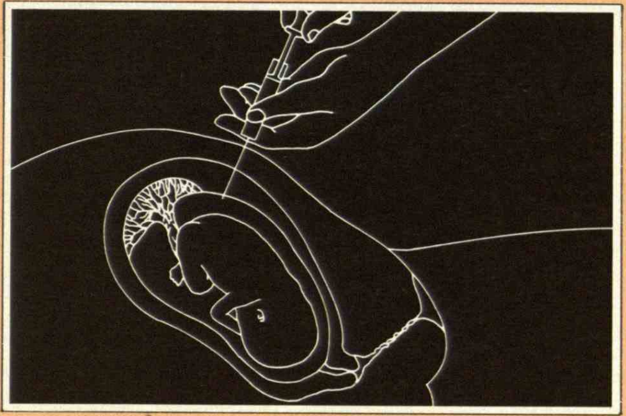
BY ELLEN RUPPEL SHELL

MARSHA Swanson was optimistic about the outcome of her second pregnancy. With a healthy five-year-old son and no history of birth defects in her family or her husband's, she was confident that all would go well. But her obstetrician cautioned that women in her age group (over 35) have a higher-than-average risk of bearing a child with birth defects. So Swanson agreed to undergo an amniocentesis, a procedure in which a small amount of fluid from the amniotic sac around the fetus is removed and cultured to concentrate the fetal cells.

Amniocentesis was performed at 18 weeks of pregnancy, the earliest point at which there is enough amniotic fluid to test safely. It took another three weeks to grow the cells in culture and examine them for abnormalities. After a month of waiting, Swanson was finally told the fetus had Down's syndrome. She had to choose between giving birth to a retarded child and undergoing a second-trimester abortion, a painful and psychologically jarring operation in which premature labor is induced.

A new technique being tested in the United States and Europe may soon provide women with a better alternative. Called chorionic villus biopsy, it is performed after only eight to ten weeks of pregnancy. This gives women who are carrying fetuses with severe defects the chance to elect the far less traumatic option of an abortion in the first trimester.





Advances in ultrasound imaging are the main reason why physicians can now attempt surgery on the unborn. With this technique, waves of sound are bounced off surfaces inside the womb, yielding detailed pictures of the fetus without subjecting mother or child to the hazards of x-rays. An ultrasound scan, as shown here, is especially effective in detecting blockages of fluid in the bladder and the build-up of excess fluid in the brain. Surgeons also use ultrasonic images to guide their instruments inside the womb—when they place a "shunt" inside a fetus' bladder to drain blocked-up urine, for example.

Physicians can diagnose serious genetic defects before birth through a procedure known as amniocentesis. A needle is used to withdraw a small amount of fluid from the amniotic sac (top). Lab specialists extract fetal cells from this sample, grow the cells in tissue culture, and analyze the culture for genetic abnormalities. Unfortunately, amniocentesis can be performed only after the eighteenth week of pregnancy, and results sometimes come too late for effective treatment or an early abortion.

New Options for Therapy

The procedure also opens up new opportunities for fetal therapy—the treatment of genetic defects in utero. The earlier in pregnancy a disorder is diagnosed and corrective therapy undertaken, the better the fetus's chances of leading a relatively normal life. Nearly 200 genetic disorders can now be detected in utero and just last fall, scientists discovered a way to detect the gene for Huntington's disease, a fatal nervous system disorder that destroys the mind and motor function. That test, which employs sophisticated gene-splicing techniques, is also expected to lead to tests for other devastating inherited diorders such as cystic fibrosis and a familial form of Alzheimer's disease. Combined with such significant advances in gene-splicing, chorionic villus biopsy could have widespread application.

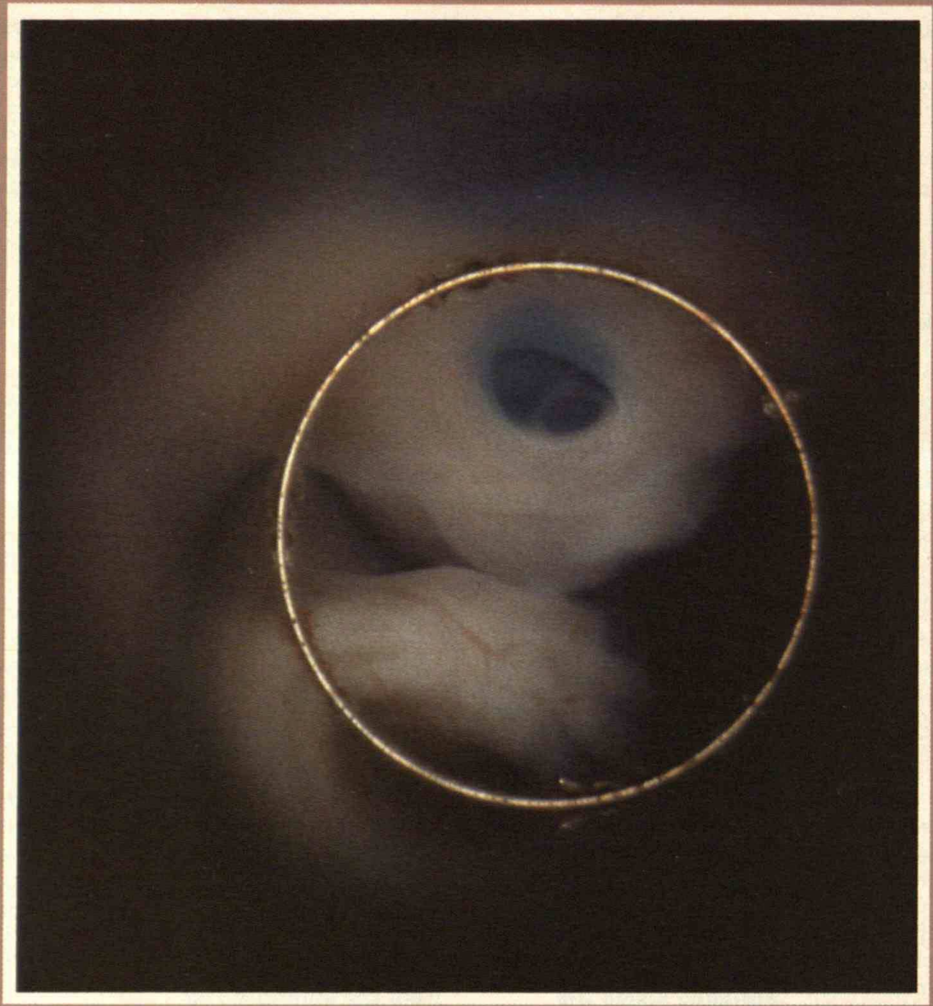
"This is a very important development," says Dr. Maurice Mahoney of Yale University's School of Medicine, "both in terms of the therapy options it might allow and the effect it will have on the women who so much want a first-trimester [as opposed to a second-trimester] abortion."

Chorionic villus biopsy is a relatively simple procedure. First the chorion—the membrane surrounding the embryo—is located with ultrasound. Then a catheter is inserted through the cervix and one or more tiny threads, or villi, of this membrane are removed. The villi are sometimes cultured to increase the number of available cells, but often they are examined directly for telltale chromosomal or biochemical aberrations. Results are available in as few as 24 hours.

Preliminary clinical tests conducted by Mahoney and others show that chorionic villus biopsy can detect genetic defects as effectively as

Continued on page 35

PHOTO: UNIVERSITY OF LEEDS TEACHING HOSPITAL; DRAWING: OMNIGRAPHICS



In the photograph above, fetoscopy reveals the head of a nine-week fetus, his hand to his mouth.

Surgeons reach for the hand of a 19-week-old monkey fetus at the beginning of an operation to relieve excess fluid in the monkey's brain. The same procedure has been performed on 25 human fetuses, with 21 infants surviving. If left untreated, the excess fluid can crush developing brain cells, causing retardation and sometimes death.

PHOTOGRAPHS: ALEXANDER TSIARAS; MARIA MICHEJDA, NATIONAL INSTITUTES OF HEALTH

A society willing to coerce a woman into fetal surgery must surely be willing to coerce a father into sacrificing a kidney for his child.

in June 1982 and the other organized by the University of Colorado in June 1983, physicians and other health professionals met to report on their experiences with fetal therapy and shape some rough guidelines for the immediate future. They found that the ethical questions divide into two types: those that face physicians and parents now, and those that will face society if the current experiments prove successful and fetal therapy becomes routine.

The most difficult clinical problem—how to choose fetuses that can best be helped by fetal therapy—also has the most immediate repercussions. By choosing wrongly, doctors could leave the future infant far more damaged, and in the worst scenario, alive only in the literal sense of the word. Physicians must also keep in mind the risk of surgery to the mother, whose body is the site of treatment. Both surgery and cesarean delivery (which is usually but not always necessary) can limit the mother's future possibilities for childbearing.

So what should guide the choice of fetal patients? The therapists who attended the 1982 meeting were able to develop general critera based on the cases treated so far. The criteria stipulate that in the two disorders now being surgically corrected in utero (congenital hydronephrosis and hydrocephalus), there must be evidence by ultrasound and other examinations that the disease is serious and progressive. If the fetus is only mildly affected, waiting until birth to begin treatment is preferred. An amniocentesis should also be done to rule out other serious chromosomal or genetic disorders. If such disorders exist, parents would then have the choice of abortion. The physicians also resolved that plans for fetal therapy should be submitted to review bodies in local hospitals before the first trial procedure. Although such review is not legally mandated for innovative fetal therapy, physicians at both conferences stressed the prudence of a prior review by a more impartial group that includes nonmedical members. The inclusion of impartial reviewers can help counter the zeal to try new treatments.

The physicians also debated whether they should operate on a twin affected with a congenital disorder when the other twin is healthy. This question was especially difficult to answer because the first fetus ever to undergo a successful operation for congenital hydronephrosis was a twin. Faced with that dilemma in 1981, physicians at the University of California chose surgically to relieve the blockage of the affected twin's urinary tract before it critically damaged his kidneys and lungs. The doctors waited until the 41-year-old mother was seven months pregnant so that the healthy female twin would have a chance to survive if the operation triggered premature labor. The operation was successful: physicians were able to drain the excessive fluid from the male twin's abdomen, and both babies were delivered normally two weeks later.

In retrospect, however, the physicians at the 1982 meeting decided they should refrain from any surgery on a twin until the treatment is no longer experimental. They concluded that their primary obligation is to minimize harm to all concerned. When the procedure is still so experimental, the risks of surgery should not be imposed on a healthy twin.

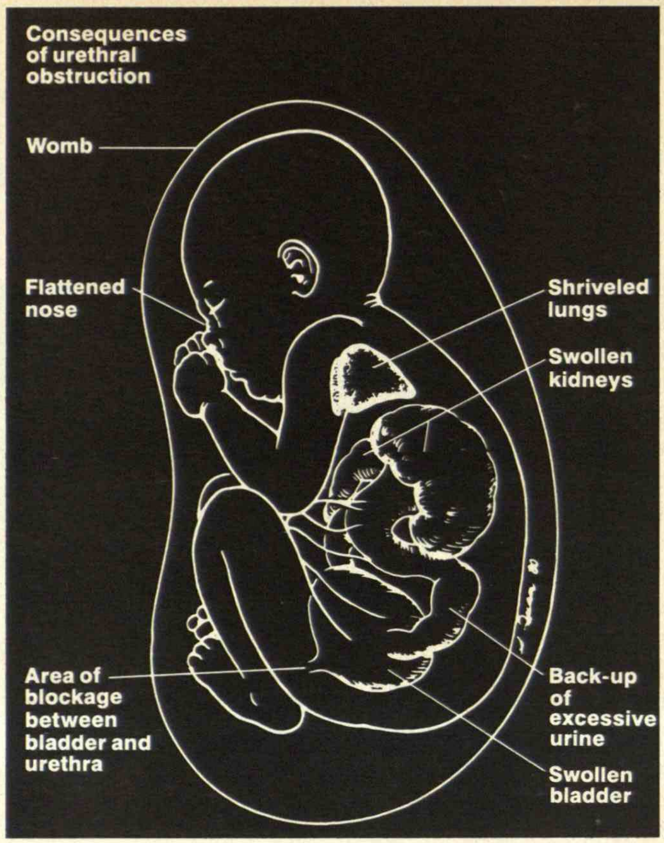
The Problem of Consent

The second immediate ethical problem involves the consent of the parents, especially the mother. The person most partial to the fetus is asked to be both the site for experimental therapy and to make an informed and voluntary choice. At the conferences on fetal therapy, physicians told stories of attempts by desperate parents to obtain surgical treatment when it was too late to intervene and would have been dangerous. Any parent would be sympathetic with their motives, which stem from the most ancient form of altruism: the loyalty of kin to kin. But mothers might be unduly influenced to sacrifice "all" for their offspring.

In the family's interests, the conferring physicians universally recommended that both parents be involved in the consent process. One medical team even included an advocate for the fetus, a disinterested physician who "spoke for" the fetus and described the benefits and risks of treatment. It was also recommended that the parents be given access to consultants on bioethics and legal issues if they desired. Many health-care institutions now provide ethics consultation for parents and other patients.

Although physicians who attended the 1982 Kroc Foundation conference were able to set up some rough guidelines for fetal therapy, a number of important ethical issues remain unresolved. What, for instance, should happen if a mother were to refuse proven fetal therapy? At present, parents have no moral or legal obligation to accept experimental fetal therapy. Until physicians are convinced, on the basis

Surgeons have attempted to repair malformations of the urinary tract in the human fetus, but results are mixed. In infants with obstructed urinary tracts, the passageway between the urethra and the bladder becomes blocked by a piece of tissue. The backed-up urine causes swelling in the abdomen and kidney. These swollen organs, in turn, inhibit lung growth. The surgical remedy involves inserting a tube that bypasses the obstruction and allows urine to flow freely.



of scientific evidence, that future infants will clearly benefit at minimal risk, no moral or legal duty to attempt a therapy exists. However, once a treatment is proven, a good moral case can be made that it *ought* to be done, if the risks to the mother are minimal. One significant—and morally relevant—exception might be if the mother refuses treatment. She might refuse on religious grounds, if she were a Jehovah's Witness or believed that God would heal the fetus without the benefits of medicine. Another scenario might involve a woman in the midst of divorce proceedings or marital conflict who did not want to deal with the complications of this pregnancy any longer.

Some rough precedents for these kinds of situations do exist. In two recent cases, pregnant women refused to have cesarean sections even though their placentas had grown into the lower part of their uteri, obstructing the internal openings through which normal delivery occurs. With this condition, known as placenta previa, labor becomes life threatening for both mother and baby, and a cesarean section is indicated. One mother, in Georgia, refused to have a cesarean on religious grounds. The other mother, in Colorado, was described as "uncooperative and belligerent." In both cases, physicans were able to obtain court orders for performing a cesarean section, but neither had to be carried out. In the first case, the diagnosis was probably incorrect and the situation was resolved without surgery. In the second, the mother relented when told of the judge's order. The important point is that courts were willing to intervene and order surgery over the mother's objection, to save the lives of mother and child.

Recently, a judge in Maryland ordered blood transfusions for a woman near death after childbirth; the woman had objected because she was a Jehovah's Witness. She had five children, and the judge argued that the children would have suffered if she died; therefore, he concluded the state had an interest in saving her life. Another Maryland judge, at a physician's request, ordered a pregnant drug addict to report to the physician for regular tests for signs of continued drug use, undoubtedly harmful to the fetus.

Is Coercion the Answer?

To my knowledge, no mother has yet refused treatment for Rh disease in the fetus, the most common form of proven fetal therapy. Objections to treatment would most likely be rare. But if objections do occur, the responses of physicians and others will break new ground in morality and the law. One would be foolish to assume that a case would never arise when the interests of a mother and the interests of a fetus at midpoint in gestation (20 to 26 weeks) would be in conflict.

Suppose, for instance, physicians were faced with this dilemma: Gradual progress in fetal surgery proves that prior to 21 weeks, correction of congenital malformations of the urinary tract saves many infants and results in normal growth and kidney development. The procedure becomes "routine" to correct that problem. Meanwhile, an ultrasound examination reveals the symptoms of this disorder in a pregnancy in which both parents are devout members of a religious group that believes divine healing will occur without surgery. Even though the woman is only 18 weeks pregnant—well within the recommended time for treatment—both she and her husband refuse surgery on religious grounds. What should the physicians do?

To begin with, they should present the strongest medical and moral reasons why surgery is the best alternative. Their argument should be based on the good that can almost always be done for the fetus with little risk to the mother. They can say, without fear of contradiction, that to provide such benefits to the fetus is their primary duty, and that a responsible parent should cooperate. They should not argue on religious grounds, which are, after all, highly subjec-

A Head Start on Birth Defects

Continued from page 31

amniocentesis. The method's safety, however, remains to be determined. So far, most researchers have performed the procedure only on women already planning to have a first-trimester abortion, regardless of the findings; in fact, the abortions are performed immediately following the biopsy. But last July two teams, one at Michael Reese Hospital in Chicago and another at Jefferson Medical College in Philadelphia, began tests on women who hoped to carry to term.

"So far we've performed the procedure on 24 women who may be carrying fetuses at significant genetic risk," explains Eugene Pergament, director of medical genetics at Michael Reese. These patients are either over 38 years of age or are known carriers of inherited diseases such as sickle-cell anemia, a blood disorder, or Tay-Sachs, a degenerative disorder of the central nervous system. Most already have at least one affected child. "Some of these women have undergone second-trimester abortions in the past and wouldn't have gotten pregnant again if they didn't have this option. In the second trimester they can feel movement and they look pregnant. The whole psychological impact of induced premature labor is very bad," says Pergament.

The Question of Safety

Twenty-two of the fetuses Pergament tested checked out normally. One fetus had a chromosomal abnormality and was aborted. In another patient, the test was unsuccessful because the physicians were unable to get the required tissue sample to adhere to the catheter. All twenty-two of the normal cases appeared healthy in ultrasound scans performed two and six weeks following the biopsy; so far the women have reported no complications resulting from the test.

Still, the risks of infection, late miscarriage, or even defects in children after birth are largely unknown. "I doubt that the risks of this procedure, when it is perfected, will be greater than those for amniocentesis," says Yale's Mahoney. But while there have been no reports of infection in this country, about 2 percent of the 130 patients who had a chorionic villus biopsy in Europe last year contracted infections. Infections resulting from aminiocentesis are far more rare. Data from Europe and the Soviet Union put the rate of miscarriage after chorionic villus biopsy at about 6 percent, while miscarriage after amniocentesis was never higher than 1 percent and now occurs in only 1 in 400 or 500 cases. These statistics are somewhat misleading, however, because spontaneous abortions are far more common before 8 weeks of pregnancy, when the biopsy is performed, than after 16 weeks, when amniocentesis takes place.

"What we don't know and what we need to know is what the spontaneous abortion rate is for the healthy embryo at eight weeks," Mahony says. "Only then can we determine what, if any, excess risk chorionic villus biopsy imposes on a healthy fetus."

Researchers hope that ultimately this technique will be used with amniocentesis to monitor the status of the fetus and the effects of any fetal therapy throughout high-risk pregnancies. But many more studies of the technique must take place before it comes into common use.

"Everybody wants to get in on this now," Pergament says. "But I'm concerned that those who use it do so with the same care with which amniocentesis is now performed. This is still an investigational procedure. We'll feel a whole lot more secure when those babies who underwent the biopsy are born healthy." □

ELLEN RUPPEL SHELL is a free-lance science and technology writer. She was formerly senior editor of Technology Illustrated.

tive, but should instead represent the best medical interests of the fetus. The parents should be provided with an opportunity to consult with legal and religious advisers. In short, the physicians' ethics should be the ethics of persuasion. If refused, the physicians could conscientiously withdraw from the case and refer the mother to another obstetrician for delivery. Or they could remain involved through delivery and attempt to treat the seriously ill infant after birth.

Should legal means be sought to force the parents to accept fetal therapy? In my view, coercion for this purpose is morally self-defeating because the very act of performing fetal surgery on an unconsenting woman would violate other principles and rights. Coercion would involve a greater social harm to the principles of bodily integrity and autonomy than to the admittedly compromised life chances of the fetus. Authorities would be wise to prevent the imposition of surgery or coerced fetal therapy of any type. Who would be willing, even under order from a court, to strap a woman down for this purpose? I suppose a "police official" could be asked to do it, but I doubt that the laws that protect patients from medical procedures without their consent are best served by such actions.

This hypothetical case does not involve the ethics of abortion, but that matter is also relevant. In a society that permits abortion through the second trimester of pregnancy, would it make sense to coerce unwilling women to undergo fetal therapy during this period? Could a court with one hand uphold the right of women to elect abortion and with the other uphold forcible surgery or other treatment for the fetus? Possibly, but not without considerable violation to the principle of justice to the women involved.

Another argument against coercive fetal therapy is that it would set a precedent for coercive practices in organ transplants and other life-saving treatment. A society willing to coerce a woman into surgery for a

The great appeal of fetal therapy is the promise of correcting diseases that could cause a lifetime of physical suffering.

nonviable but treatable fetus must surely be willing to coerce a father to sacrifice a kidney for his child. If society has gone that far in requiring parental sacrifice, what else might it be willing to do to protect the life of the young? Clearly, great harm to the public good could be done in the name of doing good to the fetus.

The pivotal persons in such conflicts are the parents, and options for fetal therapy should remain their choice. Ultimately, it is the choice of the woman in whose body the therapy will be done.

The Genetic Risks

Many child advocacy groups, including representatives of the handicapped, and right-to-life organizations have expressed concern about the purposes to which prenatal diagnosis might be put. Would it be used to screen all pregnancies at risk for a genetic disorder? Will society develop rigid and perfectionist attitudes about what constitutes a "healthy child"? Mass genetic screening programs have aroused fears that eugenic programs will be based on narrow criteria of what constitutes a healthy child. As a result, current screening efforts are strictly voluntary.

If fetal therapy is successful, it will help relieve such fears. When something helpful can be done for fetuses with malformations, the number of abortions for genetic reasons will be reduced.

Looking at the issue from another stance, some people worry that saving fetuses with genetic diseases will preserve more harmful genes in the population. Whereas babies with such malformations previously died or suffered severe damage, fetuses treated successfully will survive and probably reproduce. For instance, physicians can now screen for phenylketonuria (PKU) in newborns and prevent severe mental retardation, a result of the disease, with diet therapy. Screening for this disease began in the 1960s, and some of the newborns treated are now old enough to reproduce. Before treatment, severely retarded PKU patients did not reproduce. As their offspring are at a risk for the same disease, physicians are now debating whether to begin therapy during pregnancy.

In terms of the human gene pool, the risks from treating such a disease increase rather than diminish. Some knowledgeable geneticists are worried about these increased genetic risks to the general population. But I believe the way to alleviate this worry is simply to develop better therapy. We are all at genetic risk, since each human being carries from six to ten lethal genes. No such state of affairs as genetic perfection exists or can ever exist.

The great appeal of fetal therapy is the promise of early treatment to correct diseases that would otherwise result in a lifetime of physical suffering and economic burden. The economic considerations should be secondary to the opportunity to relieve suffering, but the economics of fetal therapy should not be passed over lightly.

More than 250,000 American infants—about 7 percent—are born each year with mental or physical handicaps. The annual costs of these disorders are high but exact figures are hard to find. In 1980, an NIH report on congenital disorders cited $1.5 billion in direct costs and another $1.4 billion in "foregone earnings," or the lost annual earnings of parents and the children who would never work. Costs of specific disorders such as spina bifida have been studied more carefully. If this disorder, currently the leading cause of paralysis in children, could be treated in utero, the savings over the lifetime of each child could be at least $100,000. Economists figured in 1977 that the cost of medical care for mild cases of spina bifida was almost $17,000 for the first 20 years of life, compared with $2,500 for medical care for a normal child. More severe cases of spina bifida would be much more expensive to treat, since many operations can be involved. A mid-1970s study of 700 families who kept careful records on the costs of treating spina bifida showed an average expenditure of almost $20,000 by the time their child was seven and one-half years old. These costs would no doubt be much higher today. Fetal surgery would also be expensive, especially at first, but would represent only a fraction of such lifetime costs.

The benefits to society are much more difficult to calculate. People free from genetic disorders would finally be able to live full lives and contribute a great deal more to society. Fetal therapy would also lift a tremendous burden from families who conceive disabled offspring. In the end, fetal therapy may turn out to be one of those rare cases where treatment not only eliminates great suffering but also cuts down significantly on the costs of medical care for parents and society.

JOHN C. FLETCHER is assistant for bioethics at the Warren G. Magnuson Clinical Center, National Institutes of Health, in Bethesda, Md.

RECALLS: WHY THEY OCCUR. HOW TO ANSWER ONE ON YOUR CAR.

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Ronald Reagan's science policy has changed considerably during the last three years. Conservatives are now trying to devise a program that links science, technology, and economics—a theme that promises to influence the presidential campaign.

The Making of a Conservative Science Policy

BY WIL LEPKOWSKI

No administration stirred the U.S. scientific and technological establishment more in its first year of office than the present one. The conservative gale that swept Ronald Reagan into office three years ago, with its promise of reversing 40 years of growing government presence in homes, offices, farms, factories, banks, classrooms, and laboratories, threatened to blow away the structures that had fostered the country's technical expertise and used it in formulating national policy for at least three decades.

In its early days, the new administration cut basic-research budgets; terminated applied research programs in fields such as fossil fuels, agriculture, and the environment; slashed support for the social sciences; and eliminated science education programs. Long-serving members of federal science advisory boards found themselves sitting next to new appointees whose major qualifications seemed to be loyalty to the neoconservative branch of thought. The scientific establishment, which had survived with equanimity a series of budget cuts, the temporary loss of the post of presidential science adviser, and other insults during the previous decade, feared that much of the experience it had gained in linking science and government was about to be sacrificed in the effort to reduce the federal presence.

ILLUSTRATIONS: YEVGENY YELCHIN

In some important senses, everything about science and technology policy has changed.

Now almost all that has changed. The Reagan administration has quietly reversed itself in program after program. Support for environmental protection, social science, and science education is being restored. Federal monies for basic and applied research are climbing. The White House has even appointed a new commission to examine the technological challenge to U.S. competitiveness, just as previous administrations have done.

As we enter a new presidential election year, faced with the enormous problems that lie ahead in a world economically driven by technology, we see that the U.S. science community probably overindulged in fear and trembling. Despite its early actions, the Reagan administration reconstructed a science and technology policy not unlike that of its predecessors. Even the two major conservative Washington think tanks, the Heritage Foundation and the American Enterprise Institute, have acknowledged the importance of science and technology by establishing policy studies in the field.

Still, in some important senses, everything about science and technology policy has changed. The Reagan advisers' perception that such policies had to conform not only to the administration's economic program but also to its ideology startled a community that traditionally regarded itself as above political ideologies. The administration has not abandoned its effort to limit the free international exchange of scientific information; its fears that the Soviet bloc will steal Western technology continue to threaten the freedom and integrity that science has historically cherished. Even when reinstated, federal support for science and technology was sprinkled more selectively than ever before, favoring projects with bottom-line potential. That emphasis disturbs much of the scientific community. However, neoconservative policymakers have finally started to tackle a fundamental issue that previous administrations have shied away from: integrating economics with science and technology.

This issue is important because we live in a brave new high-technology world. Videotext and robots surround us. Ronald Reagan entered a role of global leadership at a time when technology and science were no longer seen as an elite system, out of reach and beyond the understanding of common people and their representatives. Sci-tech is, in fact, part of a network of competing values.

Ronald Reagan swept into the presidency with a radical new mandate. He set the goal of rescuing America from its long march toward socialism through entrenched welfarism, and from accommodation with communism through policies such as detente, with its technological "giveaways." His aims were to cut government spending, balance the budget, and stoke industrial growth through tax cuts, deregulation, and relaxation of antitrust policies. Those policies would "trickle down" to the common people and provide them with an employment base fed by true wealth. "The conservative political imagination," said conservative educator and philosopher Russell Kirk, "will set to work to allay our present discontents and renew our order."

To the nation's science and technology community, this "order renewal" sounded a mite threatening. A whole funding structure lay exposed to an army of unknowns. So in its own detached way, the community paused to sniff the breezes. All it could do was sniff, however, for there was no one to talk to at the White House.

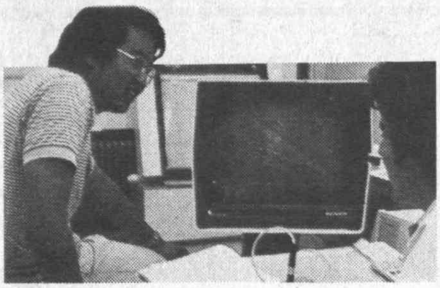
Search for a Science Policy

If the new administration had a formal technology and science policy, no one could find it. There was a science and technology transition team, containing stalwart Republicans with impeccable policymaking credentials such as Simon Ramo of TRW, William O. Baker of Bell Laboratories, and former Nixon science adviser Edward E. David of Exxon Research and Engineering. But once the administration took office, the team had to confess ignorance of the White House's intentions. Certainly the administration ignored the transition team's advice to appoint a science adviser quickly. Remembering that the same advisory apparatus had embarrassed Richard Nixon through vocal opposition to the anti-ballistic missile and the supersonic airplane, some White House insiders argued that a science adviser was unnecessary. So the administration went ahead with the goal of cutting the budget for science and technology without any input from the experts.

To conservatives, the fields that deserved the severest cuts threatened states' responsibilities for determining and carrying out social policy, and shackled business and local initiative. "Soft-core" science—sociology and environmental research, for example—was the target, and the New Right tore into it with delight.

MIT

JANUARY 1984



Also in this issue: Diana ben Aaron on forensic science . . . nuclear engineering's bitter/sweet 25th anniversary . . . how the alumni earned their president's grade of A– . . . the first freshman writing test (40% failed) . . . M.I.T.'s best-ever year for asset growth. . . . *and much more*

"I Just Wanted to See What It Was Made Of"

Student View/Diana ben-Aaron

Diana ben-Aaron, '85, is majoring in humanities and materials science. This is one of her series of essays on "Materials Scientists at Work" awarded second prize in the M.I.T. Writing Program's 1983 DeWitt Wallace Prize Competition in Science Writing for the Public.

"Modern chemical analyzers can tell a lot about where you've been and what you've done, so just remember that when you commit the perfect crime."–Dr. George Plotkin, 7.51 lecture

Sherlock Holmes could have immediately told you a few things about Arthur Gregor. From the calluses on his hands and the blunt way his fingernails are worn down, Holmes would have deduced that Gregor works with machinery and abrasives. From the acid stains on his fingers, Holmes would have told you that Gregor works with chemicals. The scratches on the lower halves of his bifocals bear witness to the fact that Gregor spends a lot of time looking through microscopes.

But exactly what does Arthur Gregor do?

He is a technical instructor in the Department of Materials Science and Engineering at M.I.T., in charge of specimen preparation and analysis; that is, he cuts things into slices, mounts them, grinds and polishes them, and examines the cross-section with microscope, camera, and microhardness tools. He is also in charge of keeping the specimen preparation equipment, which is used by the whole department, in good condition and teaching students and newcomers how to use it. But he is most enthusiastic about the analytical aspects of his work. Whether working for M.I.T. scientist or as a consultant, Gregor is motivated by an intense curiosity about what things are made of.

Warnings in Victorian Jargon

Arthur Gregor begins a tour of his lab by bringing out of his cluttered office three cardboard boxes filled with his most interesting samples. Snail shells. Rocks. A tennis racket string—someone wanted to examine the twist of the fibers in a cross-section. A piece of antique gold. "I first got interested in this stuff when I was in high school, running errands for a jeweler in Boston after school," says the 1955 M.I.T. graduate.

Most of his samples are metal. Part of the propeller from Jerome Wiesner's old boat. A dentist's drill. A piece of Volkswagen engine. "This car crashed when the brakes failed, and they wanted me to find out why the metal snapped like that." They? The police? "No, the insurance company."

Gregor is not primarily a forensic metallurgist, although, with his experience and knowledge of modern methods, he might have been able to tell Sherlock Holmes a thing or two. He has occasionally been called by the police to testify in ballistics cases, but he avoids going into detail about that, preferring to display cross-sections of his own bullets. "I used to do a lot of shooting—mostly paper targets," he explains. "I made my own bullets and everything. Every now and then, I'd take one apart to see if I was still doing the same thing. It was my own quality control."

Continued on page A29

ELIZABETH SLOTE

JOHN A. TUCKER

The New EG&G Center: All for Undergraduates

More Power for the "Miracle of Education"

Edgerton's own strobe technology captures the moment when he and his fellow-donors cut the ribbon on the new EG & G Center. Left to right: Esther M. and Harold E. Edgerton, '27; Pauline and Kenneth Germeshausen, '31; and Dorothy and Herbert Grier, '34.

The Department of Electrical Engineering and Computer Science is M.I.T.'s largest, claiming this year almost half of all the Institute's undergraduates and 80 percent of those in the School of Engineering. It teaches the largest single course in the Institute (6.001, Structure and Interpretation of Computer Programs), its laboratories are crowded, its teachers overworked.

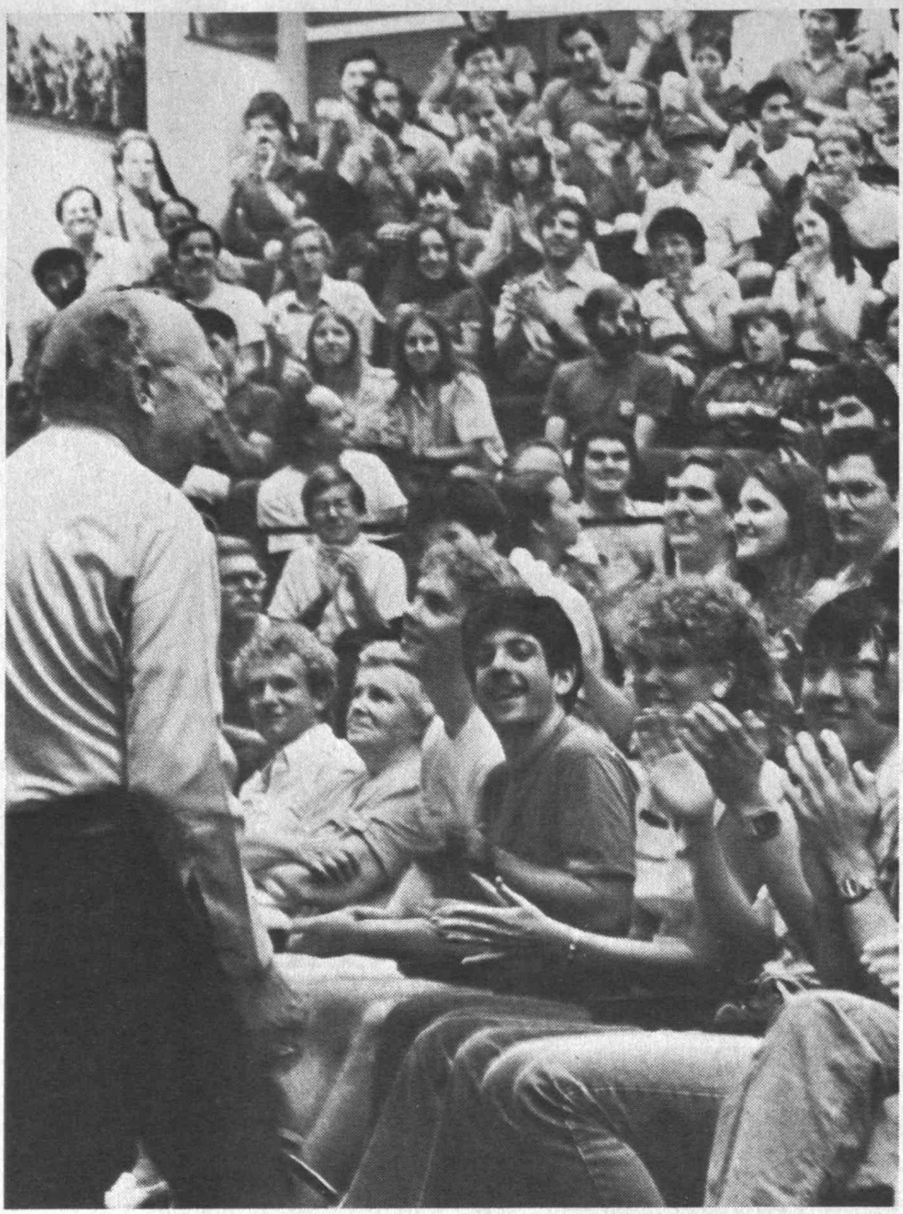
But the EECS faculty insists that the department's education is absolutely first-rate (why else would so many students come knocking on its doors?), that morale is the highest of any department in the Institute. It inspires, says Dean Gerald L. Wilson, '61, "a sense of quality, caring, and confidence that its graduates carry with them through their entire professional careers." President Paul E. Gray, '54, will himself return to its teaching ranks next term, sharing with Professor Arthur C. Smith responsibility for one section of a core subject—not yet identified.

High morale was raised even higher last fall with completion and dedication of the EG&G Education Center, a deceptively small-looking building—simple but by no means spartan—nestled between the Fairchild and Compton Buildings. Inside are a tiered lecture hall (first two floors), four classrooms (third floor), a large multi-purpose conference/seminar/lounge room (fourth floor), and a column-free undergraduate teaching laboratory filled with computer terminals (fifth floor). There are no elevators, no offices, not even a Xerox room or a lavatory, almost no space devoted to corridors: all these services are already near in Buildings 36 and 38.

The new lounge room is the department's only meeting room big enough to hold its whole faculty; the new laboratory has ended, at least for the moment, a crisis in laboratory space for computer courses, allowing 6.001 to be taught "the way we want to teach it," says Professor Joel Moses, Ph.D. '67, department head. (*see next page*).

STEPHEN A. BROBST, '87, FROM *THE TECH*

JOHN A. TUCKER



CALVIN CAMPBELL

October was "Edgerton month" at M.I.T. "Doc" inaugurated the Edgerton Lecture Hall in the new EG & G Center to a packed house (right); and at a dedication party he was the object of some good-natured fun by an EECS barber shop group (top). Earlier, "Doc" had conceived a unique "time capsule" to place under the EG & G Center—20th-century soft-drink containers, in the spirit of the many ancient amphorae that he's found.

All these spaces are primarily for faculty and undergraduates, and thus the Center emphasizes "the central role of undergraduate teaching at M.I.T.," President Gray said during dedication ceremonies on October 7. He called that "the strongest bond that holds us together," and Dr. Gray went on to propose that "nowhere at M.I.T. is this held more strongly than in EECS."

What Those Initials Really Mean

The building's name reflects the major contribution to its construction of EG&G, Inc., and plaques inside honor the contributions of the firm's three founders, Professor Harold E. Edgerton, '27, Kenneth J. Germeshausen, '31, and Herbert E. Grier, '33. Edgerton is an M.I.T. legend (*see pages A6-A9*); almost everyone at the Institute knows Germeshausen as an alumnus, benefactor, and friend. Grier, now a resident of La Jolla, Calif., is less well known in Cambridge, but Dr. Gray says "the immediacy and warmth of his response to our statement of needs was simply wonderful."

For Edgerton it began when he arrived at M.I.T. in 1926 and found "the spirit was so strong that it just burned you up. Still does," he told the dedication audience. "There's no end to this education business. To me, it's a miracle."

Germeshausen arrived at M.I.T. three years later, "green as grass." When he finished his thesis—a study of a large synchronous motor, with Edgerton—it was the bottom of the depression. No job. So Doc suggested Germeshausen help use the new strobe on industrial problems, just as he had on his thesis problem, and the first part of the partnership was put in place. Grier joined the team two years later, and ever since then he's been impressed by how innovation really is not technology but people . . . "just what you're doing here," he told the dedication audience.

Architects for the $5 million building were the Chicago office of Skidmore, Owings and Merrill. Building was by Barkan Construction Co. of Chestnut Hill, Mass.

6.001 Rescued from "Disaster"

How a Staff of 35 Teaches Computer Programming to 365 Undergraduates

By Nancye Mims

PETER MUI, '82

The new Germeshausen Laboratory atop the EG & G Center has literally rescued M.I.T.'s largest course from "disaster," says Professor Harold Abelson, Ph.D. '73. As undergraduates flocked to EECS in record numbers last fall, 365 undergraduates signed up for 6.001. More are expected this spring—a landslide that is causing M.I.T. some serious problems of maldistribution.

"Organization" is the key to teaching the largest class at M.I.T. in the largest and fastest-growing department—Electrical Engineering and Computer Science—according to Professor Harold Abelson, Ph.D.'73. He and Professor William M. Siebert, '46, head a staff of 35 teaching 6.001, Structure and Interpretation of Computer Programs, the entry-level computer programming course which boasted a record enrollment of 365 last fall.

"Things that would be minor inconveniences in smaller classes—like not having an assignment ready—turn into major catastrophes in a large class," Abelson says. To avoid such calamities, Abelson meets once a week with his teaching staff of seven faculty members, 13 graduate students, and 13 undergraduates. "It's a giant staff," he said. "You have to prepare not only for yourself but for the faculty and teaching assistants as well."

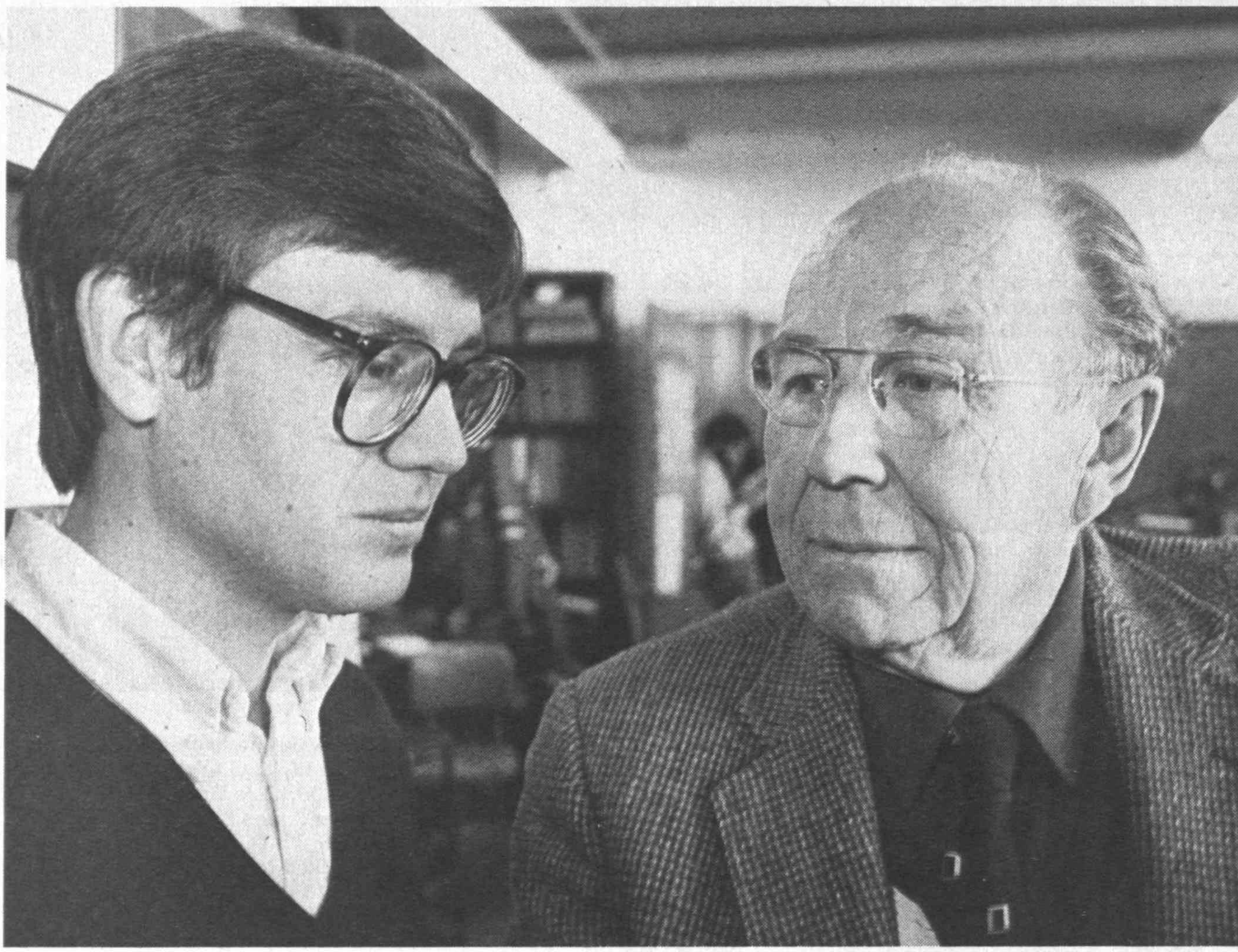
Although it involves "a lot of work," Abelson thinks the students should find it an easy course.

"I can boast that it's well taught," he says. "We try to make the ideas clear. That makes it easier. The whole course is pretty tightly organized around a particular set of ideas." Unlike the introductory computer programming courses formerly taught at M.I.T. and many still being taught at other universities across the country, Structure and Interpretation of Computer Programs emphasizes system design and the engineering principles of computer programming—in contrast to the particulars of one or more computer languages.

Abelson and Professor Gerald Sussman, '68, who together wrote the course notes that are due to be published in book form this spring by the M.I.T. Press, describe the computer revolution as a "revolution in the way we think." Thus the course stresses "techniques common to engineering design . . . and methodology."

Tight organization for a class that requires extensive work with large computer programs is not enough, though. Even with the smaller enrollments of 214 in the fall of 1982 and 281 in the spring of 1983, the load on the department's computer resources was too much, and the course was close to a "disaster" for students and teachers, according to Abelson. "It was a nightmare for students trying to finish homework. There just weren't enough computer resources."

The addition of 48 new computers this fall, however, donated by Hewlett Packard and housed in the new EG&G Education Center, is making a difference, and this term all students who preregistered for the course are in it. But if past enrollment patterns continue some students may be turned away this spring. Last spring, 600 students wanted to take 6.001, and over 300 were turned away.



PETER MUI, '82

Countless students have experienced the warmth and generosity that have made Institute Professor Harold E. Edgerton, '27, (right) an M.I.T. legend. But few have described their encounters with "Doc" more gracefully than Pepper White (*left*).

"When Can I Come to See You?" Asked White "What's the Matter with Right Now?" said Doc

By Pepper White

"Hello. May I speak with Dr. Edgerton, please?" I asked the secretary.

"Just a minute," she replied.

"Uh, hello Doctor Edgerton. My name is Pepper White, and I'm a student at the Sloan Lab, and I was wondering if I could make an appointment to talk to you about some pictures I'm taking. Do you have any time tomorrow?"

"Well, what's the matter with right now?" he replied briskly. "You busy?"

"Uh, I have a meeting with a . . ."

"You are busy. Well, how about tomorrow at 9:30?"

"O.K. I'll see you then. Thank you," I said.

The next morning I went up to Strobe Alley, the hall that is lined with pictures of bats frozen in flight, gymnasts' trajectories, golf balls being sliced, footballs being booted, bullets splitting playing cards, and lots of strobe equipment in cases. I went into the door with "Enter" painted on it and walked down to a workbench where Doc was talking to a man in his 70s. They were both holding things that looked like wet rolls of paper towels in plastic bags. There was a yellow thing that looked like a four-foot-long torpedo on the floor, and a box with "EG&G" marked on it. Doc started to put one of the paper towel rolls into the box which turned out to be a chart recorder.

"What can I do for you son?" he asked.

"I'm Pepper White, I called yesterday from the Sloan Lab. I'm working on diesel combustion."

"Yeah, I know the Sloan Lab; a young guy by the name of Draper did some work there in the thirties on a diesel engine. What are you going to do that he didn't do?"

"Well, we know more about what we're doing," I said.

"Suppose I give Stark Draper a call and tell him you said that?"

"Oh I don't think that will be necessary. I just meant that we can control our operating parameters more precisely in the rapid compression machine than he could in a real engine."

"All right," Doc said. "What's the problem?"

"Well, I'm using this rapid compression machine, and I'm trying to take some movies of a diesel fuel spray, and I thought you might be able to tell me about some of the ways of doing it. We're using a Hycam and . . ."

"You're all set then. What do you need to talk to me about?"

"Well, I thought you could tell me if there's anthing faster than what we have, or if you know of any cameras on campus that we could use that go faster."

"You'd have to talk to Charlie Miller about that," he said. "The fastest that technology goes is about 10,000 frames per second. How many frames you want?"

"50,000 would be nice," I said.

"Yep. You're just like everyone else—always trying to take pictures of more and more and you see less and less. Now if you'd take a single exposure with a fraction-of-a-microsecond flash, that might be educational. Then you could see the individual droplets, get some good resolution. We like to take a 4x5 and then blow it up to a couple of feet by a couple of feet, and then you begin to really see what's going on. How would you like to try that?"

"Sure," I said. "I'd like to have the best picture of a diesel fuel spray that has ever been taken."

"Good. This here is Billy MacRoberts. He's my technician. Let's the three of us see what we can find."

"Most of the Film Goes in the Trash"

So we went over to the notebook where they kept records of equipment they'd loaned out, and it turned out that the guy in the test cell right next to mine had just what I needed out on loan since 1981. The return date promised was May 25, 1981, and today was May 23, 1983.

"It's due in two days," Doc said. "Oh, that's 1981 not 1983. Where is this Vilchis guy anyway?", referring to the name on the form.

"He's graduated a year ago," I said.

"Well, let's go down there and see if we can find that stuff," Doc said.

So he and I walked to my lab. I showed him the timing electronics we'd installed and explained how we'd shot our high-speed movies. The guy in the lab next door wasn't around and the lab supervisor couldn't find the stuff, so I asked Doc if he'd like to see the movie I'd made while we waited for the guy from next door to come back.

"Sure, let's take a look," he said.

I pulled out the projector and set it up, trying not to seem like a klutz and mess up the threading of the film. It took a little longer than normal, but I did get it done.

"It takes most of the film to get to the place where we see what's happening. The HYCAM was getting up to speed," I said.

"Yeah, that's the problem with this high-speed photography business. Most of the film goes in the trash," Doc replied.

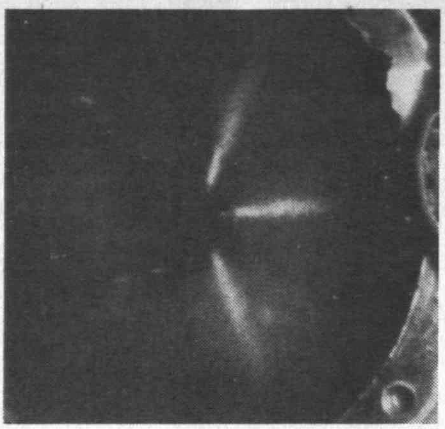
A couple of minutes later the fuel jet showed up on the screen. It was well lit and pretty clear. "You can imagine the first time I ran this thing—waiting to see if I caught the injection," I said.

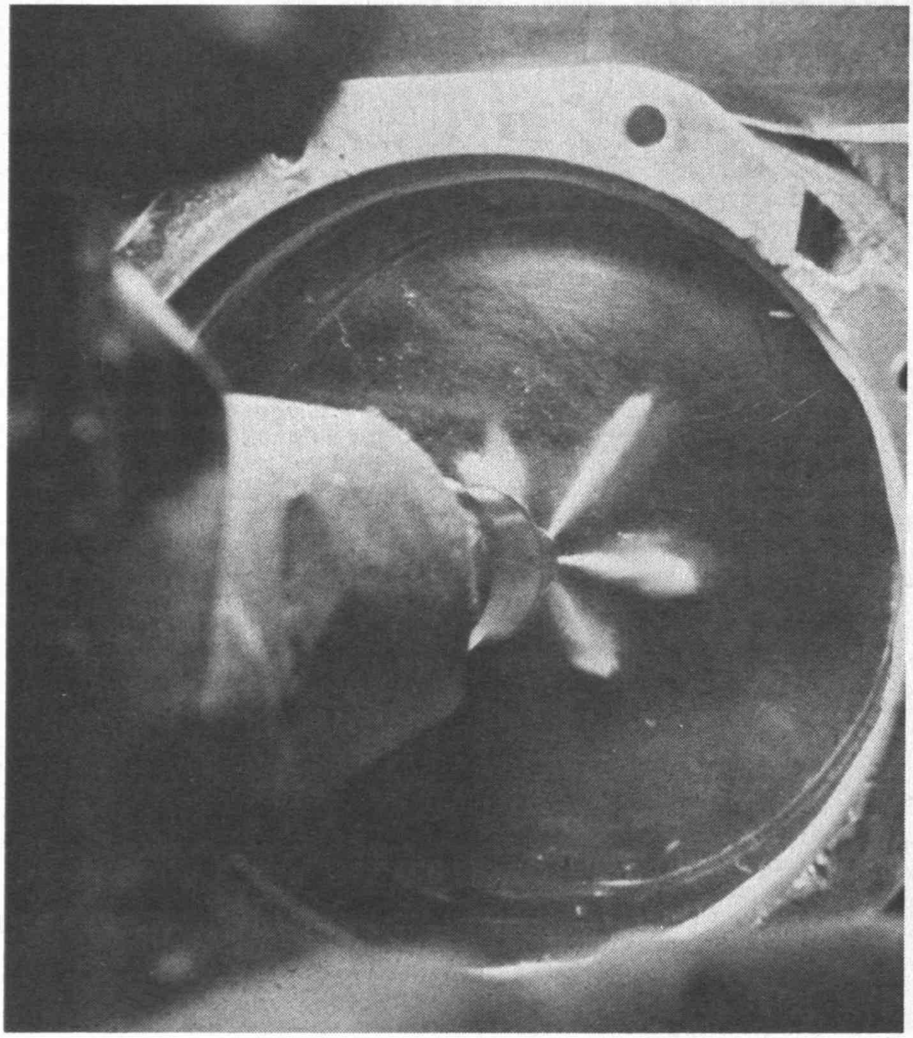
"That's a good picture. It *must* have been a thrill when you saw it the first time." I knew he understood that thrill better than anyone else in the world.

"Let's Get Billy to Fix It"

By then the guy next door was back, so we went down and looked through his cell and found some doodads that Bill had made that were now in the random junk section of the storage cabinet. "Yeah, this is the stuff," Doc said. "Let's take it back to the lab and get Billy to fix it."

The spark for the flash had melted the plastic housing and split it right open. Doc told a story: "Once we had one of





The injection of diesel fuel into a rapid compression machine. The high-speed flash "freezes" the fuel droplets' motion, revealing turbulence in the fuel jet. No such detail is visible in the top photograph, illuminated with a conventional flash bulb. (Photos: Pepper White)

these and found that plastic wire wrapped around it absorbed most of the heat and almost kept it from breaking. So we put twice as much plastic around and it worked. That's engi-neering."

When we got back to the strobe lab I saw on Doc's wall a picture of something that looked like a slowly melting golf ball on the top of a metal frame.

"Is that what I think it is?" I asked Doc.

"Yeah," he said, "That's a small atom bomb they were trying to get to work back in the 40s. We had to take that with a rotating shutter and a magnetic polarizer. Those things let out a lot of light, you know."

"When I was doing some reading for my thesis I found an AEC paper from about 1945 on 'The Rapid Rise of a Buoyant Plume'. I think they might have been talking about the same thing," I said.

"Sounds like it duzinit?" Doc said.

Just Like a Spark Plug, Only More Powerful

Bill was still loading water into the sidescan sonar paper-towel rolls. "The guy says he brought it back," Doc said. "Some guy named MacRoberts must have forgotten to write it down when he did."

"Or some guy named Edgerton," Bill retorted.

"Well, let's get this guy fixed up," Doc said, referring to me, "and get him out of here so we can get some work done. Come on, let's go into the other room and see what we can loan him."

So we crossed the hall and went into the other half of the lab. It looked like pictures you see of M.I.T. and say wow to when you're taking physics in high school. There were lots of strobe lights on benches, the famous wheel that has circles on it that stand still under the strobe light depending on the speed, electronic boxes, and behind me there was a .22-caliber rifle mounted horizontally on a bench. There was a piece of cardboard behind it; it was painted

"What's inside that?" I asked. "Oh, it's just some sand we picked up at Revere Beach. It kills a lot of energy," Doc said.

black and I could have done the job myself.

"Is this it?" I asked impetuously, knowing Doc would know what I was talking about.

"Yeah," he said. "Usually we use a .45-caliber pistol, but it makes too much noise. We did a demonstration for some high-schoolers the other day, and I didn't want to blast their ears out. If you look over there you'll see we have to catch the bullet with something," and he pointed to something that looked like a Chlorox bottle.

"What's inside that?" I asked, thinking it'd be something like flak jacket material.

"Oh, it's just some sand we picked up at Revere Beach. It kills a lot of energy," Doc replied.

Bill was pulling a couple of electronicsy-looking boxes off the back of the bench. They were strictly analog—stuff that makes you think of old pictures of M.I.T. wartime research. Both of the boxes had tags on them that said "EG&G." Billy also picked up a thing that looked like a test tube with some wires coming out of it.

"Shall we see if this one works, Doc?" Bill asked.

"Sure, plug it in," Doc answered. He started to explain it to me while Bill was connecting the wires. "Billy's seen everything fail at least once, so he knows what to do about it when it happens. He should be able to fix this thing up in a jiffy. See, you got two capacitors, one 8,500 volts positive, one 8,500 volts negative, for 17,000 volts. That'll give you a nice kick if you touch it the wrong way."

Bill had all the wires in now, and he pressed the little button that said "manual." And POP there was a white flash so bright I thought that by now Billy and Doc would have been blinded from seeing that so many times.

"That's a fraction of a microsecond," Doc said. "Here, take a look at that," he said, pointing to the other little glass tube inside the test tube. "That thing there is what we call the stinger. The high voltage ionizes the gas in between the electrodes here and then the impedence goes down and the spark jumps across. It's just a spark plug, only a little more powerful."

The tubes were making a clicking noise, and I was trying to see why. "Corona discharge," Doc said. "Put enough voltage across a gap and those little electrons are just dying to hop over to the low voltage side."

I wanted to get some of this down on paper, but I'd left my notebook in the lab. "Do you have a sheet of paper I could take some notes on?" I asked.

"Sure. Here." He gave me a wasted polaroid print that had one corner torn off it.

"We got everything, Billy?" Doc asked.

"Sure do, Doc," Bill replied.

So we went across the hall again. "We gotta fix you up with a shield now, so the flash doesn't just go straight to the camera and that's all you see. Billy, can you make one up for this fella?"

Sure thing, Doc." Bill cut a little piece of aluminum and then rolled it through a bender, and it fit perfectly on the test tube.

"He need anything else now?" Doc asked.

"Just a circuit to keep the power surge from going back to his trigger."

"Well, why don't you two go back to the other room and see if you can find one. I've gotta go through my mail now."

So Bill and I went over to the other room again. Bill did a quick calculation of the instantaneous power the strobe takes—a mere 6 megawatts. Coulombs and volts were as tangible to him as inches and pounds were to me. We couldn't find the circuit around, so Bill told me to go back and talk to Doc while he, Bill, looked for the circuit.

They Only Want Successes

Doc was still going through his mail. "Got something here from Koosta," he said. "You know Koosta first came here back in 1952. He was young and nobody'd ever heard of him. So I told every student in the class I was teaching then that if they didn't bring ten of their friends to the talk he was giving it was going to be . . ." and Doc drew his index finger across his neck. "It worked," he said. "There was standing room only for the talk, and the guy who arranged for the room couldn't even get into a lecture hall that seats 800."

I was a little confused until I got a peek at the letter and saw that it was signed by Jacques Cousteau.

"You read French?" Doc asked.

"Yes, I do," I replied and started reading the text of the letter.

"It looks like they want me to fill out this questionnaire for some book they're doing about their ship's voyages," Doc said. "What's the question?"

"Uh, I think it means they want to know how many times you were on voyages with the ship. If it's one or less they don't want you to fill out the form."

"Think eight'll qualify?" Doc quipped. "How about this one here?"

"They want copies of any pictures you took during the voyages," I replied.

"We've got 2,000. Wouldn't they have a fun time picking the best ones out of that many?"

By then Bill had found the circuit. "I only could find one, Doc," he said.

"Well, give it here, I'll make him a drawing. He's a grown man—he can build the circuit himself," Doc said.

Doc sketched it up in a minute, and I ran down to make some copies. I came back and gave the original back to him.

As they were loading up my arms with the equipment Doc issued the conditions of the loan. "We don't like to loan to people who aren't successful, so work hard and get some good pictures," he mandated.

"I'll have some for you in a week," I promised—and it worked and I did.

Pepper White is a graduate student in the Sloan Automotive Engine Laboratory at M.I.T.

With E. P. Brooks, 1956

With Alfred Sloan, 1962

BRADFORD HERZOG, 1983

How M.I.T. Grew to Become a Part of Howard W. Johnson, and Vice Versa

A Contagious Spirit of Excellence, He Says

Howard W. Johnson has been a visible and influential leader in the M.I.T. community for nearly 30 years—first as director of the Sloan School's executive development programs, then as its dean, then as president of the Institute (1966-71) and chairman of the Corporation (1971-83). Now he is an M.I.T. teacher (on leave, 1983-84) once more. As Mr. Johnson was leaving his duties as chairman of the Corporation last summer, Technology Review *talked with him about experiences and recollections in this remarkably long period of Institute leadership.*

ALL PHOTOGRAPHS COURTESY M.I.T. MUSEUM

With Paul Fye at WHOI, 1967


Receiving the Charter from Jim Killian, 1966

TR: A headline in the *New York Times* when you were elected president of M.I.T. read "M.I.T. Hires Back Top Dean." You had taken another job. . . .

Johnson: Well, I had decided to leave M.I.T. I was sitting in my office as dean, having served for six years, and the school was moving very well. And one day I was literally, out of the blue, asked whether I would be the executive vice-president of a very big company. And as I thought about it, it seemed to me that was the ultimate test for a business school dean. We were trying to educate young people for careers in management, and here I was being offered a chance to run a company in the billion dollar class with a lot of complicated problems all over the country. It seemed to me that if I turned that down I would be missing a test that would be worth facing. So I accepted.

Then on the eve—in fact, it was past the eve—of our leaving (our furniture was being loaded, and going; we'd sold the house; our children were enrolled in other schools; and I was in a farewell meeting in the Sloan School) there was a phone call that I was told I had to take. It was Vannevar Bush, saying, "I've got a couple of people in my office, can we come by and chat with you?"

When they walked in I knew who they were, even though there were some I had known only by reputation, like Crawford Greenewalt, Ed Hanley, Jim Fisk, and Robert Gunness. They spent an hour and a half with me. They began with vague questions like, "What do you think the job of the president of M.I.T. is?" It was no mystery to me after a few minutes. But I sometimes wish I had a transcript of that conversation because I would like to know what I answered to some of those questions.

TR: How did you feel at that point, having already turned your sights towards the midwest?

Johnson: I didn't really have to debate that with myself. I thought then, and I think now, that the job of president of M.I.T. is one of the most important posts in education. Elting Morison long before I got the job called the presidency of M.I.T. one of the 20 most interesting jobs in the world. So when Jim Killian asked me on behalf of the Corporation, I said, "Yes." I didn't even say, "I'll call you back."

"I thought then, and I think now, that the job of president of M.I.T. is one of the most important jobs in education."

TR: But you had to call off your other plans, right?

Johnson: That was more complicated, because my new job with Federated Stores was well publicized in the *New York Times* and elsewhere. And here it was, December 20, and I was supposed to report for work on January 1. When I met Fred Lazarus, who was then chairman of Federated, he listened to two minutes of my description of what had happened. And then he said, "Howard, there's no question about what you should do. You should be at M.I.T."

TR: Did you ever have second thoughts about missing that chance to test yourself in the real world as a practitioner of the theory of management?

Johnson: I still think that's an interesting and worthwhile idea. And I think it applies to a school of management perhaps more than any of the other academic departments. But no; I have no regrets at all.

TR: Clearly, lots of us have shared your experience of finding M.I.T. a hard place to leave. What makes it so?

Johnson: I believe this institution is one of the few that not only lives up to its reputation when you're inside it—it

CALVIN CAMPBELL

With Walter Mondale, 1980

Kresge faculty meeting, 1969

ROBERT LYON

With Pusey, Moynihan, and Cabot on Urban Studies, 1967

goes beyond that reputation. It becomes part of you.

TR: Is this a commentary on your colleagues? On the students?

Johnson: It's those two, surely. When we recruit a great professor to come to M.I.T., we always talk about the faculty and the students first. But it's more than that. It's an institution with very high standards, and I think its demands are contagious—so challenging that they may well be unique. I remember looking out our window occasionally in the middle of the night, and the lights are always on. It's a place that doesn't go to sleep.

And I think it's even more compelling than it used to be. Once the great people who were here took pride in calling M.I.T. "the factory on the Charles." They were proud of the almost-barren physical surround. But now it's very different—a place with great working ambience, but one that embodies the arts as well as science. And then there's the most visible change of all—the fact that women are a real part of our community. It used to be a man's world. The year I became president of M.I.T. there were 14 women in the freshman class. Now there are 275.

I don't mean by this that the education we offer now is notably better than it used to be. I think through its history the Institute has always been an outstanding institution for educating the best-equipped young people to deal with their times. The traditional values—learning how to solve problems, learning to stick with something when it's difficult, learning to work hard—those remain. And the most important things about the students remain the same: they are very bright, they are very strongly motivated to do something important with their lives. If I ask a alumnus 10 years out, 20 years out: What did you learn at M.I.T.? Was it worthwhile? Yes, it was worthwhile. What did you learn? I learned problem-solving processes, I learned to work hard, to be tenacious about it, and not give up.

TR: Do you feel that M.I.T. students have changed during the time you've been here?

"The basic goals of any president are to make sure that the faculty remains strong and that in the process of choosing our students we can and do draw on the country's very best young people."

Johnson: In all the years I've been here the students have been the most brightly polished exemplars of their time, and if their society has had special goals, they tend to reflect them. In the 1960s we experienced the coming together of all those revolutions—the torment of Vietnam, the war which the students saw as intolerable before anybody else; the demands for rights for minorities—women and blacks. These were situations that had to change. It was a torrent, and nobody could avoid it. That's different now. Now a student can be a private individual, very much turned inward, if he or she wants to be. It's a much more individualistic society now than it was then.

TR: As you recall your experiences in the two top offices here, what were the questions that made a big difference?

Johnson: First would be the question of whether the faculty could and would remain together as a working body—a body in which disagreement could take place on important issues yet that would hold together in support of a process that served M.I.T.'s long-run educational and research programs. It did so, and magnificently, too. Then there was the debate surrounding continuing the core curriculum—a set of requirements of fore-needed knowledge

Harvard Commencement, 1966

CALVIN CAMPBELL

With Frank Press and Jerry Wiesner, 1978

CALVIN CAMPBELL

With Jay Stratton and Paul Gray, 1980

DOV ISAACS, '71

and honed abilities. M.I.T. stayed with those requirements during a time of a general departure from the core concept. There was also the issue of our commitment that any qualified student should be able to come here without regard to financial resources—that we should meet all students' legitimate needs. I felt strongly about this, and we stayed that way against a lot of pressures. Another policy: we decided to keep our graduate enrollments constant when many others were cutting theirs. We maintained our commitment to a learning environment—the dormitories, the fraternities, the athletics—when a lot of people were having to draw back.

Next, the world of the future will insist on full opportunity for women and for minority groups in science and technology as well as in the world in general. M.I.T. took the lead during those years in this area. The problem of minority access without changing the standard is something in which I fervently believe deserves to be a prime requirement for M.I.T. There are other curriculum issues—the past/fail grades in the freshman year so we don't discourage our best and brightest students in their first year of association with the fire hose treatment of the Institute, our decisions to reach out to other institutions like Wellesley and Woods Hole. I also remember the questions about whether to abandon or to renew some departments, for example our Chemical Engineering Department at the time when chemical engineering departments were being closed down all over the country. We decided to go ahead, and it turned out to be literally on the eve of the energy crisis.

"My most important advice to any president is to make sure we stay a cohesive, communicating institution."

In the final analysis, I think the basic goals of any president are to make sure that the faculty remains strong and that in the process of choosing our students we can and do draw on the country's very best young people.

One of our greatest characteristics here is that we have one faculty. That's going to be very important in the future, and I think my most important advice to any president is to make sure we stay a cohesive, communicating institution.

TR: What are you leaving for your successor to do as chairman of the Corporation?

Johnson: Lots, and that's worth a point. We still have the never-ending battle of assuring M.I.T.'s financial strength and stability. That's a sub-set of a very tough question: Can private education, broadly speaking, remain a prime contributer to American life? I think that the way in which the country deals with the problems of private education will be the principal issue in front of us for the next couple of generations.

TR: Now you've moved back to the Sloan School—for the sake of nostalgia? Do you have any specific plans for the next few years? A book?

Johnson: I have a professorship at M.I.T. that the faculty voted me—which I'm grateful for. I can hold it for my lifetime, and I can teach in any department that will have me. The Sloan School, among others, did invite me, and for the next few years I'd like to try to understand how to give our students an opportunity to study the theory and practice of human organizations. That's a very difficult thing to do, and I think our undergraduates, who go on to such remarkable professional and technical responsibilities, need a chance to think as deeply about those complex problems as they have to think about many technical issues. I look forward keenly to that challenge—really as keenly as to any other I've had since I came to M.I.T. 29 years ago.

The NAC Message: Thanks—But Can You Reach Out Still More?

Mann Rates the Alumni at A-; The Challenge of Change

At least 5,000 alumni volunteers work for M.I.T. every year—raising money, interviewing students, arranging club meetings, helping fellow-alumni, writing for this magazine. . . . If each contributes 10 hours a year—a fair average, thinks William J. Hecht, '61, the Alumni Association executive vice-president—then their services are worth at least $5 million to M.I.T.

But in fact those services are beyond price, says Hecht—"absolutely essential" to the Institute.

The annual National Alumni Conferences—this year on September 23 and 24 in Cambridge—have two seemingly contradictory purposes with respect to this vast outpouring of good will and support: to express the Institute's thanks for it in the past, and to urge even more of it in the future.

For their recent performance, Robert W. Mann, '50, president of the Alumni Association for 1983-84, gives the alumni a grade of A-. That's not really a criticism of what's been done in the past, he told the annual meeting session of the 1983 NAC. For the Institute is much blessed with a body of alumni who have "a keen understanding of the role alumni can play . . . aggressive in their purpose of fostering alumni interest and support." Among its many assets, the Alumni Association that serves them has "a vigorous, articulate, and forceful board of directors," and a magazine that is "a unique instrument for the discussion of public policy as influenced by technology."

The minus on that grade of A conveys Mann's sense of the need "to reach out still more" toward an ever-growing alumni body. And that task, he said in his annual report to the NAC, will be complicated by the fact that increasing numbers of future alumni will not fit the molds of the past. More will live in the sun belt and overseas, more will be women and minorities, and more will be holders of graduate, rather than undergraduate, degrees. Those issues—and especially the need to provide continuing educational opportunities—are no trivial agenda for the Alumni Associaton. But he believes it "poised for more vigorous and effective pursuit of the goal," Mann told over 300 alumni colleagues at the Association's annual business meeting.

Target: $9.4 Million in 1984

As chairman of the Alumni Fund Board, James K. Littwitz, '42, brought to the annual meeting the most tangible evidence of alumni support—the record of over $8.6 million given to the Institute through the 1982-83 Alumni Fund from a record 26,811 contributors. But Littwitz called his a "bitter-sweet report," for in two respects, he thinks, alumni giving falls short:

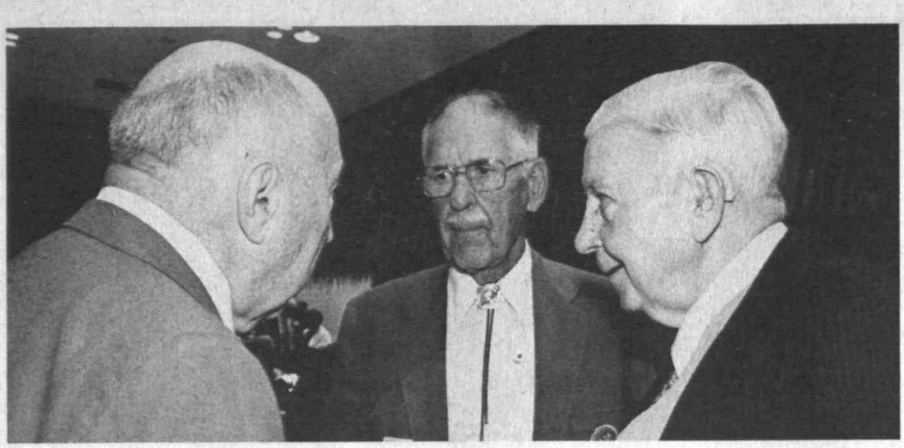
☐ The median gift is now only $40, despite a "major" recent effort to raise it.

☐ Only 33 percent of alumni with graduate degrees from M.I.T. (in contrast to 50 percent of undergraduate alumni) are fund participants.

The targets for this year's 1984 Alumni Fund suggest impatience with these shortfalls, Littwitz said: total giving of $9.4 million from 27,600 participants. And the Fund Board wants at least 30 percent of all contributions to be over $100 (compared to 27 percent today) by the 1985 Fund year.

Tapping the Power of Computers

These results will help support an institution committed to education and innovation that is now beginning what President Paul E. Gray, '54, called "the most exciting adventure it has ever undertaken." Gray, speaking at the NAC dinner on September 23, was referring to Project Athena, which he described as "a massive, experimental program to tap the power of computers to help students learn in every department and every discipline." The adjectives most frequently used at briefing sessions, Dr. Gray said, are "interactive" and "dynamic." The most important idea is



Opposite: Five winners of the coveted Bronze Beaver pose as President Robert W. Mann, '50, invokes applause from the 1983 Awards Luncheon audience. From left to right, the winners are Horace W. McCurdy, '22, Wayne J. Holman, S.M.'39, Ernest U. Backman, '46, Robert C. Cowen, '49, and Russell N. Cox, '49. George M. Keller, '48, sixth winner, couldn't be present.

On this page, clockwise from above. Three long-time comrades in service to M.I.T.—Carole A. Clarke, '21, Donald G. Morse, '21, and James R. Killian, Jr., '26. Congratulations to Mary F. Wagley, '47, from Robert T. Howard, Jr. '42; when she takes office next summer, Ms. Wagley will be the first woman to lead the Alumni Association as president. And congratulations to James K. Littwitz, '42, chairman of the Alumni Fund Board, from President Paul E. Gray, '54.

"coherence"—the goal that the intellectual achievements of every user of Athena can be available to every other user in whatever field. And the users may soon enough include alumni, said Gerald L. Wilson, '61, dean of engineering, proposing that they may be invited to network their computers in the field with those of Athena at M.I.T.

A surprise announcement at the dinner: Mary F. Wagley, '47, will be president of the Alumni Association in 1984-85. Her early selection means that she can have a full year to learn about the Association's activities before assuming responsibility for them, Mann explained. Ms. Wagley was introduced as the first woman president-elect of the Association, and she will make 1947 the 13th class to give the Association three presidents. (The other two are Claude W. Brenner (1979-80) and Harl P. Aldrich 1980-81).

A series of awards to honor alumni for their services to the Institute at the annual Awards Luncheon on September 24. There were Lobdell Awards for distinguished service to **Kenneth Armstead,** '75 ("for contributions to the Black Alumni of M.I.T. (BAMIT) during its formative years"); **C. William Carson,** '52 ("for creative, thoughtful leadership of the M.I.T. Club of Southern California"); the late **James E. Cunningham,** '57 (for "dedicated service to the Class of 1957"); **Philip G. Dreissigacker,** '37 (for "outstanding contributions" to the M.I.T. Club of New Haven, the Alumni Fund, and the Educational Council); **Sumner Hayward,** '21 (for "40 years of distinguished service to his class and the M.I.T. Club of Northern New Jersey"); **William N. Hosely,** '48 (for "consistent and valuable leadership" for the M.I.T. Club of Rochester); **Christina H. Jansen,** '63, and **Lita D. Nelsen,** '64 ("for pioneering a highly successful workshop for women during seven consecutive IAPs); **Carol C. Martin,** '77 (for "enthusiastic, effective service to her class"); **Hector M. Orozco,** '45 ("the mainstay of the M.I.T. Club of Mexico and the Mexican Fiesta"); and **Viguen R. Ter-Minassian,** '64 (for "thoughtful and substantive contributions in the Washington, D.C., area").

Toronto and Houston in 1984

To give alumni living far from Chicago a better chance to participate, the National Alumni Conference will be held in two locations in 1984: Toronto on September 21 and 22 and Houston on October 12 and 13. Further details will be available by spring from Joseph J. Martori, associate secretary of the Association, at Room 10-110, M.I.T.

Six awards of the Bronze Beaver, the Association's highest recognition for alumni service to M.I.T., were announced at the luncheon:

☐ **Ernest U. Buckman,** '46, "an effective leader and key resource . . . an exemplary alumnus. . . loyalty, devotion, and deep appreciation."

☐ **Robert C. Cowen,** '49, "for 20 years a principal counselor, friend, and contributor to *Technology Review*.

☐ **Russell N. Cox,** '49, "major contributions to the Alumni Association and to the Institute" through student affairs, the fraternity system, and the Enterprise Forum.

☐ **Wayne J. Holman,** S.M.'39, "unstinting support to the Sloan School," a loyal alumnus "ready to say 'yes' to any reasonable request."

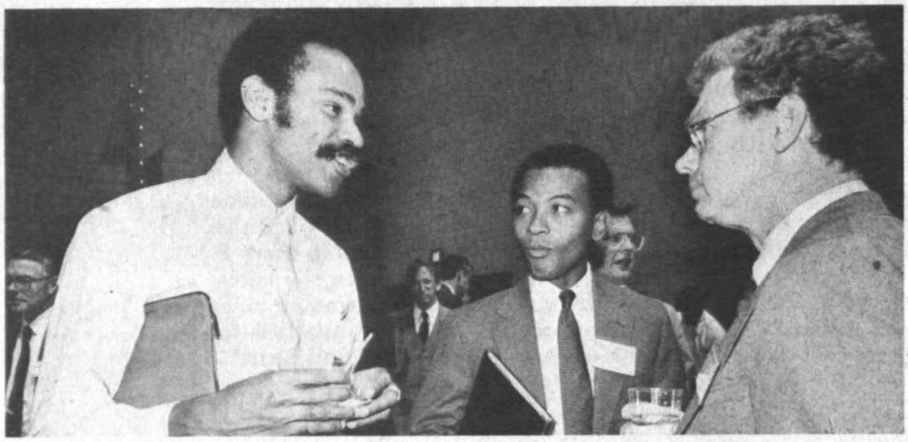
☐ **George M. Keller,** '48, volunteer service that has been "truly remarkable in breadth and depth" for more than 20 years.

☐ **Horace W. McCurdy,** '22, "Mr. M.I.T. of the Puget Sound," for "a lifetime of creative, responsible involvement with M.I.T."

There were also six Presidential Citations for contributions by organized alumni groups:

☐ **The Black Alumni of M.I.T. (BAMIT)** for their role in the M.I.T. Black Students' Conference on Science

ALL PHOTOS BY SCOTT GLOBUS, '84



and Technology.

□ **The Cardinal and Gray Society,** "a highlight in the development of meaningful activities for senior alumni."

□ **The Department of Electrical Engineering and Computer Science,** for a centennial celebration that provided "a unique mixture of intellectual programming and a sense of friendship and collegial partnership."

□ **The Class of 1977 Fifth Reunion Committee,** for its effort ("without precedent in the recent history of the Alumni Fund") to raise a fifth reunion gift.

□ **The "Technology/Rochester" Symposium** of March 1982, an "exemplary" conference that provides a model for using local alumni resources to increase community awareness of M.I.T."

□ **The Sloan School of Management,** for "its recently enforced commitment to its alumni."

Six awards named on honor of George B. Morgan, '20, were given for distinguished service by Honorary Secretaries and to the Educational Council: **Charles Bossi,** '42 of Dayton, Ohio; **Dexter Clough, II,** '35, of Bangor, Maine; **George Heller,** '59, of Menlo Park, Calif.; **Guillermo Machado-Mendoza,** '46, of Caracas, Venezuela; **Marshall McCuen,** '40, of Indianapolis, Ind.; and **Arnold Singer,** '48, of Houston.

Among those present at the 1983 National Alumni Conference (clockwise from the left): James N. Phinney of the New York office with S. James Goldstein, '46. President Robert W. Mann, '50, making his annual report. Communications specialist David A. Tedone leads an Alumni Fund workshop. William R. Tibbs, Jr., '75, Kenneth J. Armstead, '75, and Warren A. Seamans, director of the M.I.T. Museum. Robert C. Cowen, '49, Bruce D. Sunstein, '65, Charles Hieken, '51, and Martin J. O'Donnell, '58, comparing notes.

Courses

I

Civil Engineering

A significant increase in interest in civil engineering by undergraduates this year, says **Joseph M. Sussman,** Ph.D.'68, head of the department at M.I.T. Reasons: there's now an undersupply of civil engineers, and students are suddenly aware of the country's need for reconstruction that is chiefly a challenge for civil engineers. Sussman's prediction was that the number of sophomores electing Course I at M.I.T. might nearly double from last year's 18.

Victor C. Li, who joined the M.I.T. faculty two years ago, is now Edgerton Professor in the department; he's honored for his contributions to the study of earthquake rupture mechanics and concrete deterioration.

James V. Hamel, S.M.'66, of Hamel Geotechnical Consultants, Monroeville, Penn., has been elected to a three-year term as a director of the Pittsburgh section of the American Society of Civil Engineers. . . . **Burton B. Bruce,** S.M.'38, writes, "Currently, as a major portion of my retirement activities, I am editor of the *USMA-1934 Fifty Year Book*. . . . **Harry C. Saxe,** Sc.D.'52, formerly professor of civil engineering at the University of Louisville, Ky., has been named to the recently endowed Colonel Louis S. LeTellier Chair of The Citadel — The Military College of South Carolina.

Leonardo Miranda, S.M.'66, an aerospace engineer from Chula Vista, Calif., passed away on May 17, 1983. Selected by the Air Force to attend M.I.T., in 1971, he received the Good Service and Commendation Medal for his work as an aerospace facilities engineer in the Space and Missiles Organization, and was discharged in 1971 with the rank of captain. Following his military service he worked for the Naval Air Rework Facility, North Island, Calif., bringing him several awards for meritorious service. . . . **Marshall R. Jones,** S.M.'63, of Mineola, N.Y., passed away on June 1, 1983; no details are available.

II

Mechanical Engineering

Anthony T. Patera, '78, is now the Rockwell Assistant Professor of Mechanical Engineering, occupying a chair funded at M.I.T. by Rockwell International Corp. Patera is a member of the department's Fluid and Thermal Sciences Division, where he's become recognized for work in computational fluid dynamics and turbulence in fluid flows.

A specialist in the microstructure of steel and its effects on strength, Assistant Professor **Lallit Anand** of the department at M.I.T. has been awarded an Edgerton Professorship; he'll use the extra funding to extend his research interests and to involve undergraduates in his laboratory.

Roger S. Mecca, S.M.'73, has been named chairman of the Department of Anesthesiology at Danbury Hospital, Conn. Prior to joining the staff (at Danbury Hospital), he was a senior staff anesthesiologist and director of resident education in anesthesia at Wilford Hall Air Force Medical Center, San Antonio, Tex. . . . **Henry A. Morgan, Jr.,** S.M.'66, with Stone and Webster, Oak Ridge, Tenn., since 1979, has recently been appointed the engineering firm's project manager for the Clinch River Breeder Reactor Plant Project. Before coming to Oak Ridge, Morgan had management responsibility for four nuclear power plants and two solar units for Stone and Webster, and for 20 years as a naval officer he was involved in naval nuclear systems management. . . . **Erwin G. Loewen,** Sc.D.'52, a project manager for Bausch & Lomb, was elected a fellow of the Optical Society of America in October 1982 and recently received the 1983 Frederick W. Taylor Research Medal of the Society of Manufacturing Engineers.

Merlen C. Bullock, S.M.'42, who was a member of the senior engineering staff at B.F. Goodrich Co. prior to retirement and since then was actively involved with area Boy Scouts and honored for 50 years of service to youth, passed away on September 17, 1982, in Akron, Ohio. . . . **John A. Barclay,** S.M.'36, of Huntsville, Ala., passed away on May 28, 1983; no details are available.

III

Materials Science and Engineering

Paul E. Rainey, S.M.'68, formerly associate professor in the Department of Engineering Technology at Texas A&M University, is now chairman of the Technology department at Western Washington University, Bellingham. He had been on the faculty of Texas A&M since 1979 and served as acting chairman of the Engineering Technology Department and the mechanical engineering program during the 1982-83 academic year.. . . **Raymond Fessler,** Sc.D.'65, has been named manager of the Transportation and Structures Department, Battelle Columbus Laboratories, Ohio. Joining Battelle in 1965, he held a number of research and management posts while leading a special worldwide study to forecast technological trends regarding composite materials.

Firoze E. Katrak, Sc.D.'79, has been promoted to vice-president of the Natural Resources Group at Charles River Associates, Boston, consulting on business, economic, and technological issues in the minerals and metals industry. . . . **Robert Mehrabain,** Sc.D.'69, formerly director of materials science at the U.S. Commerce Department's National Bureau of Standards, has been named dean of the College of Engineering at the University of California, Santa Barbara.

IV

Architecture

Neville A. Powers, M.Arch.'72, reports that he has joined Applicon/Schlumberger as a principal applications engineer. . . . **C. Herbert Wheller, Jr.,** M.Arch.'40, writes, "Elected in 1981 to the Council of Delegates of the Union of Internationale des Architectes in charge of the professional development groups for education and practice, and concurrently I am permanent secretary of the professional development work group."

William W. Caudill, M.Arch.'47, founder of the architectural, engineering and construction firm, CRS Group, Inc., Houston, Tex., passed away on June 25, 1983. Widely known as architect, educator and author, he lectured in the U.S. and abroad on design, and was the architect of many successful schools and other buildings. Caudill pioneered the "architecture by team" method; he was a founding member of the Academy of Texas and a member of the American Institute of Architects. Two of his books: *Toward Better School Design*, and *Architecture by Team*. . . . **Miguel A. Barasorda,** '59, of Rio Piedras, P.R., passed away on December 30, 1981; no details are available.

V

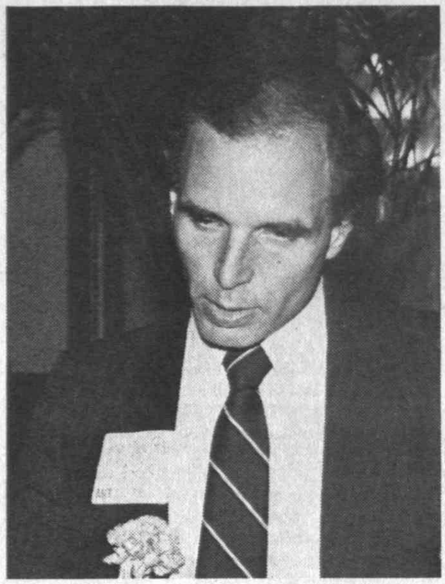
Chemistry

Professor **Gregory A. Petsko** has received a grant under the W. R. Grace & Co. research agreement with M.I.T. for a program of research on the structural basis of protein stability.

Avery A. Morton, Ph.D.'24, emeritus professor of chemistry, celebrated his 90th birthday in 1982. He is reported by Chester E. Claff, Jr., '50, and Edward R. Atkinson, '33, in the *Nucleus* (Northeast Section, American Chemical Society) to be continuing an active life, "commuting from his home in Watertown to M.I.T. by the MBTA. His 1964 Olds fell apart a while back so he now uses rental cars to drive to Rhode Island to see his great-grandchildren. He is obviously out to equal or surpass the feats of E. Emmett Reid and Joel Hildebrand who were publishing at age 100. His long familiarity with alkali metals has led him to some conclusions about the fundamental nature of the alkali metal halides, and he is currently composing an exposition of his ideas."

Anthony P. Malinauska, Ph.D.'62, has been appointed director of Nuclear Regulatory Commission programs at the Oak Ridge National Laboratory (ORNL). Since 1974 he was manager of ORNL's chemical development section in the Chemical Technology Division, involved in the development of nuclear fuel reprocessing, separation science, gas kinetic theory, and aerosol physics. . . . **Charles V. Berney,** S.M.'54, senior research associate in nuclear engineering at M.I.T., has been elected president of the New England Gilbert and Sullivan Society. He recently attended a symposium at Syracuse University on the interpretation of the Gilbert and Sullivan operas. . . . **J. Robert Emery,** S.M.'49, has retired after 34 years of service at the DuPont Co., Wilmington, Del. He joined the firm in 1949 as a chemist at the Rayon Research Laboratory in Richmond, Va., then in 1966 transferred to Geneva, Switzerland, as marketing director of Textile Fibers (Europe) where he was named managing director; and finally returned in 1971 to Wilmington. He became director of the End-Use Marketing Division in 1977. . . . **David L. Morse,** Ph.D.'76, has been appointed an associate research chemist in the Re-

Don Ritter, Sc.D.'66, is one of a handful of engineers in Congress. This picture was made at a reception for alumni Congressmen tendered by the M.I.T. Club of Washington this fall *(see page A27).*



JEAN GWALTNEY

Ritter on Risk

How do federal agencies weigh risks to the public as they make decisions on what hazards to regulate, and by what means?

In too many different ways, thinks Congressman Don Ritter, Sc.D. '66 (R-Pa.). Different laws and regulations often specify different ways of analyzing risk. Some courts have required risk assessments where Congress said nothing about evaluating risk at all. And, said Congressman Ritter in an address to his colleagues on the House floor earlier this year, in at least one case risk is being assessed "in different ways under the same law."

Such inconsistencies, Ritter told his Congressional colleagues, leave the regulated community "uncertain as to the impact of our laws and . . . less able to plan for the future. And the American people," he said, "are frequently left without an adequate understanding of why an agency takes, or fails to take, action concerning risk."

In H.R.3840 (the Risk Assessment Research and Demonstration Act of 1983), Ritter proposes a two-stage program to reduce this confusion: a 12-month study of existing risk assessment procedures, culminating in recommendations or needed research and demonstration projects that would then be conducted during a second 12-month period. In a final report, due 30 months after enactment, the researchers would tell Congress "how risk assessment processes can be improved" and Americans how to "better understand and appreciate the efforts of our federal agencies to control the risks that affect their daily lives."

search and Development Division of Corning Glass Works, Corning, N.Y.

Leo F. McKenney, Ph.D.'36, who had a long career on the staff of Lever Brothers Co. in Cambridge and Edgewater, N.J., before retiring in 1972, passed away on August 19, 1983. While working in Edgewater he had been an active member of several New Jersey school boards, and upon retirement, when he moved to Hanover, N.H., McKenney became active in Dartmouth alumni affairs. . . . **Daniel B.F. Clapp,** Ph.D.'35, of Esher, Surrey, England, passed away in 1982; no details are available. . . . **Bertram D. Kribben,** S.M., '33, of Winnetka, Ill., passed away on June 17, 1983; no details are available.

VI

Electrical Engineering and Computer Science

Jeffrey H. Lang, '75, has been chosen for an Edgerton Professorship at M.I.T. A member of the department since 1980, Lang has specialized in electromechanical design in a range of applications from electric motors to space systems. The Edgerton Professorship will provide funding to extend and involve undergraduates in this research.

Add another to the long list of honors given **Harold E. Edgerton,** Sc.D.'31: the prestigious Founders Award of the National Academy of Engineering, NAE's highest tribute. The citation: "For his seminal achievements in ultra-high speed photography which have captured and revealed hitherto unseen beauty and order in phenomena which range from the arts to underwater archeological exploration; and for unselfishly giving of himself to generations of students and many different endeavors."

Karen Wieckert, a Ph.D. student in the department at M.I.T. whose thesis will be in the field of artificial intelligence and the social issues of computing, is the winner of a Congressional Fellowship from the Women's Research and Education Institute. She's at work in Washington as a staff member of the House Subcommittee on Science, Research, and Technology, studying issues in the social implications of information technology.

Charles A. Desoer, Sc.D.'53, of the University of California at Berkeley writes, "On June 23, 1983, I received the American Automatic Control Council Education Award for outstanding contributions and distinguished leadership in automatic control education." . . . **Oleg V. Fedoroff,** S.M.'63, has recently accepted the position of senior engineer with IBM Federal Systems Divsion, Gaithersburg, Md. . . . **David P. Reed,** Ph.D.'79, has been named chief scientist and director of the newly formed Research and Exploratory Development Group of Software Arts, New York City. Since 1978, he has been an assistant professor of computer science and engineering and head of the Computer Systems Structure Group at M.I.T., while serving as a consultant to IBM and Hewlett Packard as well as to Software Arts. . . . **Stewart E. Miller,** S.M.'41, retired, effective October 1, 1983, after 43 years of service in telecommunications research at Bell Laboratories, Short Hills, N.J. He has also been director of BTL's Guided Wave Research Laboratory since 1958. While at Bell Laboratories, he "was the first to take the challenge of making lightwaves a viable way of communicating," says Arno Penzias, vice-president of research, making "a dramatic change in a key aspect of telecommunications."

Frank Gregg Kear, Sr., Sc.D.'33, a retired telecommunications consultant specializing in television and a captain in the U.S. Naval Reserve, passed away on July 22, 1983. During World War II Kear was chief of the Radio Section in the Navy Bureau of Aeronautics, and after the war he founded the consulting firm of Kear and Kennedy, Chevy Chase, Md., from which he retired in 1972. He was a member of the Society of Motion Pictures and Television Engineers and the Association of Federal Communications Consulting Engineers. . . . **Robert R. Wagstaff,** S.M.'37, a retired senior vice-president and director of United Engineers and Constructors, Inc., Philadelphia, Penn., passed away on May 16, 1983. He directed the engineering of a number of large coal and nuclear generating stations, steel plants, and chemical facilities throughout the United States and Canada. A fellow of IEEE, Wagstaff was active on many national standards committees in electrical engineering.. . . **Akim S. Zaburunov,** '39, of Fort Collins, Col., passed away on June 10, 1983 and **Arthur W. Carlson,** S.M.'52, of Harrison, Maine, on June 5, 1983; no details are available.

VI-A Program

Alumni, faculty, and students celebrated, during the week of October 4th through 7th, the acceptance and dedication of Course VI's new EG&G Education Center, which had been completed just in time for the opening of classes on September 12th. On the evening of Registration Day, **Harold E. "Doc" Edgerton,** '27, had the pleasure of giving the inaugural lecture in the hall bearing his name. The lecture, "History of Strobe Photography," was highly acclaimed and was attended by an overflow crowd (the hall seats 325). "Doc" also had the honor of giving the first lecture of the re-established EECS Colloquium Series on Monday of the celebrations week.

Other special activities of the celebrations week included:

□ A party Tuesday afternoon in the new atrium and adjacent Building 36 lobby for all the students and staff of the Department. A feature was a special barbershop 'quintet' organized by **Michael A. Isnardi,** '82, (currently on his Ph.D. program in VI). A song was sung to "Doc" who had been placed in a chair and draped with a sheet—a scene that brought a great deal of amusement and laughter. Another was sung to Professor **Joel Moses,** Ph.D.'67, department head, also seated in the "barber's chair."

A dinner for the donors with faculty and senior administrative officials of the Institute was held Thursday evening at the M.I.T. Faculty Club to express thanks, followed on Friday by the formal dedication ceremonies *(see page A3)*. VI-A alumnus **Cecil H. Green,** '23, life member, emeritus, of the M.I.T. Corporation and Honorary Director, Texas Instruments, Inc., was among the dignitaries attending. The building now completes the original plans for a concentrated focus on campus for the

faculty, staff, and students of Course VI, and we are most grateful to our benefactors. (The Grier Conference Room, incidentally, will be the location for this year's annual VI-A meeting of companies and faculty on Monday afternoon, March 5, 1984.)

This fall's on-campus recruiting season saw a number of VI-As back representing their companies. Those stopping by the VI-A office included **James L. Fenton,** '78, for Watkins-Johnson of San Jose, Calif., and **Peter J. Waldo,** '81, for Linkabit of San Diego, Calif. John Tucker had lunch with **Steven K. Ladd,** '81, interviewing for Megatest, Santa Clara, Calif., and with **S. Dana Seccombe,** '70, team leader for the Hewlett-Packard Co. interviewers, himself from Loveland, Colo.

Other visitors to the VI-A office, as of this writing, have included **Thomas R. Crawford,** '76, with Southwest Venture Partners, Dallas, Tex., and **Gary K. Montress,** '69, accompanied by his wife and 3-year old daughter. Gary is with United Technology Research Corp., Hartford, Conn.—John A. Tucker, Director, VI-A Program, Room 38-473, M.I.T., Cambridge, MA 02139

VII

Biology

American Cancer Society grants totalling $400,000 came to six members of the department at M.I.T. late in 1983: Professor **David Botstein** (molecular genetics of eukaryotes inprokaryotes), Professor **Malcolm L. Gefter,** (gene expression in mammalian cells), Professor **Alexander Rich,** (molecular structure of substances related to the nucleic acids), **William Solomon,** (structure of chromatin of globogenes), Professor **Graham C. Walker,** (genetic fidelity and DNA methylation in prokaryotes), and **Lawrence Wysocki,** (the genetic base of expression in antibodies). Six members of the department faculty have received grants for research under funds provided to M.I.T. by W.R. Grace and Co. in the field of microbiology: **Malcolm L. Gefter** (immunity to infectious agents), **Leonard P. Guarente** (isolation of yeast nuclear cytochrome genes), **H. Robert Horvitz,** '68 (cloning of C. Elegans genes by the purification of DNA from free duplications), **Robert T. Sauer** (thermal stability of proteins), **Paul R. Schimmel,** Ph.D.'67 (construction and production of enzyme fragments and polyproteins), and **Graham C. Walker** (plasmid biology and vector design).

VIII

Physics

Michael K. Wilkinson, Ph.D.'50, of the Solid State Division of the Oak Ridge National Laboratory, Tenn., has been elected a fellow of the American Association for the Advancement of Science. . . . **Norman F. Derby,** Ph.D.'76, a member of the science faculty (since 1978) at Bennington College, Vt., has been named to a term as dean of studies. Before coming to Bennington, he taught (from 1976-78) in a freshman honors program at the University of Delaware. . . . **Eric D. Thompson,** Ph.D.'60, who has been recognized as a research pioneer, teacher, and administrator in the field of electronic and semiconductor materials for more than 20 years, has been named Chandler-Weaver Professor and chairman of electrical engineering and computer science at Lehigh University, Bethlehem, Penn. Thompson, who has served on the faculty at Case Western Reserve University, was most recently program director in the Division of Materials, National Science Foundation.

X

Chemical Engineering

Three members of the department are sharing in the first allotment of research funds under M.I.T.'s agreement with W.R. Grace & Co. in the field of microbiology. Grants are to Professor **Clark K. Colton** (large-scale isolation of biological compounds by immunabsorbents), Professor **Charles L. Cooney,** Ph.D.'70 (microbial production of serine), and Professor **T. Alan Hatton** (liquid-liquid extraction of biopolymers). . . . **W. Kenneth Davis,** S.M.'42, a consultant with Bechtel Power Corp., San Francisco, Calif., and former deputy secretary of the United States Department of Energy, received the 1983 Founders Award of the American Institute of Chemical Engineers for his "accomplishments in the field of nuclear engineering and development of alternative energy sources." Earlier in the year, Davis was honored with the Department of Energy's Gold Medal for Distinguished Service (for "outstanding leadership in furtherance of the energy programs of the nation"), and in 1982 he won the National Engineering Award of the American Association of Engineering Societies (for outstanding contributions to the engineering profession). Davis was with Bechtel for more than 20 years before taking his DOE assignment, and he is a past president of AIChE.

Frank W. Bailey, '46, associated with Bailey Burners, Inc., Haskell, N.J., passed away in 1982; no details are available.

XI

Urban Studies and Planning

Michael O'Hare, formerly associate professor of urban studies and planning; **Lawrence Bacow,** '72, associate professor of law and environmental policy, and **Debra Sanderson,** M.C.P.'77, assistant secretary of environmental affairs in Massachusetts, are authors of *Facility Siting and Public Opposition* (New York: Van Nostrand Reinhold, 1983, $28.50). It's described as a guide for developers who want to use compensation to encourage communities to accept otherwise undesirable facilities that society needs but no one wants in his or her own backyard.

Professor **Lawrence E. Susskind,** Ph.D.'73, is now acting executive director of a newly-established program in negotiation at Harvard Law School. It's a collaborative project, with M.I.T. among the participants, on improving the theory and practice of conflict resolution; Susskind is also director of the project's Public Disputes Program, a study of how mediated negotiation can improve resource allocation decisions in the public sector.

Francis T. Ventre, Ph.D.'73, formerly senior research architect and chief of the Environmental Design Research Division in the Center for Building Technology at the National Bureau of Standards, is currently professor of environmental design and policy and director of the Environmental Systems Laboratory in the College of Architecture and Urban Studies, Virginia Polytechnic Institute, Blacksburg. . . . **Frederic W. Todd,** M.C.P.'68, reports that he is a principal in the architectural and planning firm of Hammer Kiefer and Todd, Inc., Cambridge, which is active in new construction and renovation throughout New England.

Robert K. Bofah, Ph.D.'71, of Goaso, Ghana, passed away in 1983; no details are available.

XII

Earth, Atmospheric, and Planetary Sciences

Robert Bowman, Ph.D.'55, employed with Texas Instruments since 1959 where he held several positions—the lastest in deployment of computer-related services—passed away on August 9, 1983, in Dallas, Tex.

XIII

Ocean Engineering

Professor **Arthur B. Baggeroer** has been appointed M.I.T. director of the Joint Program in Oceanography and Oceanographic Engineering with Woods Hole Oceanographic Institution effective July 1, 1983. . . . Professor **Ernst G. Frankel,** S.M.'60, is on a leave of absence for the 1983-84 academic year. He has been appointed an advisor on ports, shipping, and aviation for the World Bank, Washington, D.C. . . . Professor **T. Francis Ogilvie** has been appointed to the Executive Council of the Society of Naval Architects and Marine Engineers (SNAME). . . . Professor **Judith T. Kildow** has been appointed to the Board on Ocean Science and Policy (BOSP), National Research Council, through June 1985. . . . **John E. Bertrand,** S.M.'72, skipper of the 1983 America's Cup winner, *Australia II*, has shown that Course XIII grads mean business. Congratulations to John and his crew! Congratulations are also in order for **Halsey C. Herreshoff,** S,M.'60, who gave the Aussies a run for their money as navigator for *Liberty*.

The fourth annual Robert Bruce Wallace Academic Prize was awarded to **William B. Coney,** (S.B. expected '84). The prize is a gift of Mr. and Mrs. A.H. Chatfield to bring advanced ideas in ocean engineering to the M.I.T. community and to the public. Mrs. Chatfield is the daughter of the late **Robert Bruce Wallace,** '98, who was president of the American Ship Building Co. and made major contributions to inland waterways shipping.

Professors **Justin E. Kerwin,** Ph.D.'61, and **Robert J. Van Houten,** Ph.D.'76, have been named winners of the Captain Joseph H. Linnard Prize for 1983 for the best paper contributed to the 1982 SNAME Annual Meeting. The winning paper: "Theoretical and Experimental Propeller-Induced Hull Pressures Arising from Intermittent Blade Cavitatation, Loading and Thickness." . . . **James S. Uhlman,** Ph.D.'83, has won the student paper competition of LIPS Propeller Works, Druuen, Holland. He presented his paper in Holland on May 19-20, 1983. . . . **George Triantafyllou,** Ph.D.'83, won the 1983 SNAME Graduate Paper Award. His paper which he presented to the New England Section of SNAME last spring was on the hydroelastic behavior of membranes in parallel-flow mineral collecting systems.

Professor **J. Kim Vandiver,** Ph.D.'75, received the ASME Arthur Lubinski Award for Best Petroleum Mechanical Engineering paper at the 1983 Offshore Technology Conference in Houston, Tex. . . . **Monica A. Schnitger,** '82, has returned to M.I.T. as a graduate student after spending one year at Bath Iron Works, Bath, Maine. Monica is spending some time helping out in the Student Adminstration Office while Ms. Joanne Luciano is on maternity leave.

Harold L. Young, S.M.'60, supervisor of shipbulding at Electric Boat, Groton, Conn., since March 1981, has been reassigned to Washington, D.C., as second-in-command of the Navy office overseeing all submarine construction. His previous assignment (1979-81) was shipyard commander of the Portsmouth Naval Shipyard. . . . **James E. Grabb,** S.M.'60, recently retired from the Coast Guard as a captain with over 30 years of service, has assumed the position of technical director with the American Society of Naval Engineers, Inc., Alexandria, Va. James writes that the ASNE is very interested in receiving original technical papers for publications in the *Naval Engineers Journal* and possible presentation at one of the society's symposia.—Patricia A. LeBlanc-Gedney, Administration Officer, Course XIII, Room 5-228A, M.I.T., Cambridge, MA 02139

XIV

Economics

Alice Kidder, Ph.D.'67, has been appointed associate professor of management at Babson College and also director of the Office of Sponsored Research. For 12 years she was an economics professor at North Carolina Agriculture and Technical State University, then moving to Syracuse University where she was associate professor of transpor-

tation. . . . **A. Lawrence Kolbe,** Ph.D.'79, has been promoted to vice-president at Charles River Associates, Boston, the economics/management consulting firm. He has authored several papers and a forthcoming M.I.T. Press book dealing with the cost of capital estimation. His assignment at CRA is in regulatory and financial economics, investment evaluation, applied microeconomics, and energy transportation economics.

XV

Management

Just before the death of **Gordon Y Billard,** '24, this fall *(see page A30)*, **Lester C. Thurow,** professor of management and economics, was named to the Billard Professorship, a chair created by Billard's recent gifts to M.I.T. In making his gifts, the late Mr. Billard, whose M.I.T. degree was in business and engineering administration, specified his interest in "national and international issues relating to economics, finance, and politics," and **Abraham J. Siegal,** dean of the Sloan School, says no one fits that prescription better than Thurow.

Alvin J. Silk, professor of management science and associate dean of the school, now holds the Erwin H. Schell Professorship. Schell, who graduated from M.I.T. in 1912, was a member of the Economic Department from 1917 to 1930 and then for 21 years head of the course in business and engineering administration before the founding of the Sloan School; the professorship is funded by alumni in Schell's honor. Silk's field is marketing and his recent research is on models to support decisions in marketing communications and new product development.

Frank P. Davidson, head of macroengineering in the System Dynamics Group, is the author of *Macro* (William Morrow & Co., 1983). It's an account of large-scale engineering projects of the past, present, and future—and of Davidson's adventures in researching the sponsorship and conduct of macroengineering.

Peter F. Hollings, S.M.'73, writes, "This September my family and I moved from the Boston area to Fairfield, Conn., from where I commute to the New York office of Booz, Allen & Hamilton. I joined the Booz, Allen consulting practice as a senior associate." . . . **Lance Heiko,** S.M.'75, has been named a visiting assistant professor in the management division of Babson College for the 1983-84 academic year. Since 1979 until the summer of 1981 he was program manager for the solar applications branch of TVA.

Sloan Fellows

Donald W. Male, S.M.'58, has been appointed secretary of the Unitarian Universalist Association.. . . **Gerhard Schulmeyer,** S.M.'74, assistant general manager of the Automotive and Industrial Electronics Group of Motorola, Inc., Schaumburg, Ill., has been elected a corporate vice-president of the firm. In 1980 he joined Motorola's Automotive Products Division as vice-president and general manager of European operations and managing director of Motorola, GmbH, Munich, West Germany, being promoted to his present position in 1982.

Management of Technology Program

Geoffrey N. Andrews, S.M.'82, came for a brief visit to M.I.T. in October and met all the current class members. He is now chief project engineer at Pilkington P.E. in North Wales, a position he took last spring. On a more personal note, he reports his family is doing well. His 4-year old daughter has started school this year and is learning Welsh!. . . **John A. Harrison,** S.M.'83, reports that he left Bechtel in September to join Parson Brinckerhoff Quade and Douglas in New York City. He is working as assistant project manager on the Pennsylvania High-Speed Intercity Passenger Rail Study, and he and Bonnie were looking for a house in the

Continued on page A23

25 Years of Nuclear Engineering

No Pessimists Here: the Nuclear Option Alive and Vital

Seven students showed up outside his door when newcomer Manson Benedict, Ph.D.'35, returned to the Institute in 1952 to offer a course called Nuclear Reactor Engineering I in the Chemical Engineering Department. But only one year later Professor Benedict had an assistant, there were three courses and 19 students, and M.I.T. was ready to give its first master's degree in this exotic new field devoted to turning the extraordinary power of the atommic nucleus to man's peaceful use.

In 1954, saying that "the development of atomic energy for beneficient use is important to the spirit of America," President James R. Killian, Jr., '26, committed M.I.T. to building one of the first research reactors at a U.S. university. The Atomic Energy Commission had only in that year declassified the technology of nuclear reactors for research and power production.

By 1957, 31 master's degrees were given in nuclear engineering, a year later the first doctorate, and then suddenly Manson Benedict found himself the first head of a new department.

Many would say that the promise of those auspicious years has now dimmed almost to extinction. But no one in Cambridge last October 8 could think so, for vitality as well as good fellowship pervaded the reunion of 125 of the department's alumni, back to celebrate with 75 of today's students and faculty the department's 25th anniversary.

Would any of the department's founders have promised 25 years ago that this extraordinary "fuel-less" energy could power more than 10 percent of America's lights in 1983? Yes, indeed: they were optimistic then, and they are now—and on the offensive, too.

Nuclear power—fission or fusion or both—is the only economic source of electricity for the long-term future, said John Deutch, '61, dean of the School of Science. He is struck, said Deutch, by "the incongruity between the importance of nuclear energy for the future of the U.S. and the grotesque, fantastic trouble it's in."

And in the most exciting of the day's symposia, a team of faculty proposed a new program of research to revitalize the nuclear option.

Fission, Fusion Yes; Breeder No

Already there is a significant shortage of engineers to operate and maintain today's nuclear plants and to complete and operate the new ones now being built. One out of every eight jobs in the industry was unfilled in 1982, said Nunzio J. Palladino, chairman of the Nuclear Regulatory Commission, and lots of those who held jobs need new training and retraining. No single thing will restore public confidence in nuclear power, Palladino said, but accident-free operation by skillful operators is an essential ingredient.

Deutch's enthusiasm for nuclear power—fission and fusion both—is unlimited . . . so important, he said, that improving conventional fission and developing fusion ought to have the nation's full attention.

That leaves out the breeder reactor? asked a voice in the audience. Indeed it

does, said Deutch. Continuing effort on that project is "terribly wrong," he declared—doubling the troubles of the nuclear industry, drawing resources away from needed improvements on the fission system, and leading to "progressive political difficulties" from which Deutch sees "no way out. . . . The nuclear industry," he declared, "has not seen the importance of stressing the light-water reactor."

Fusion won Deutch's enthusiasm—"a remarkably promising resource in the long term," he said, and a "perfect technical problem"—an interdisciplinary problem requiring many different skills and stimulating many different disciplines. The problem now is to achieve the community-wide acceptance of the fusion program that will assure its future stability through a sense of common purpose.

$2 Million for Fission

The nuclear optimism was maintained in the afternoon when seven members of the department reported on a summer study of options for improving conventional fission plants. The oppor-

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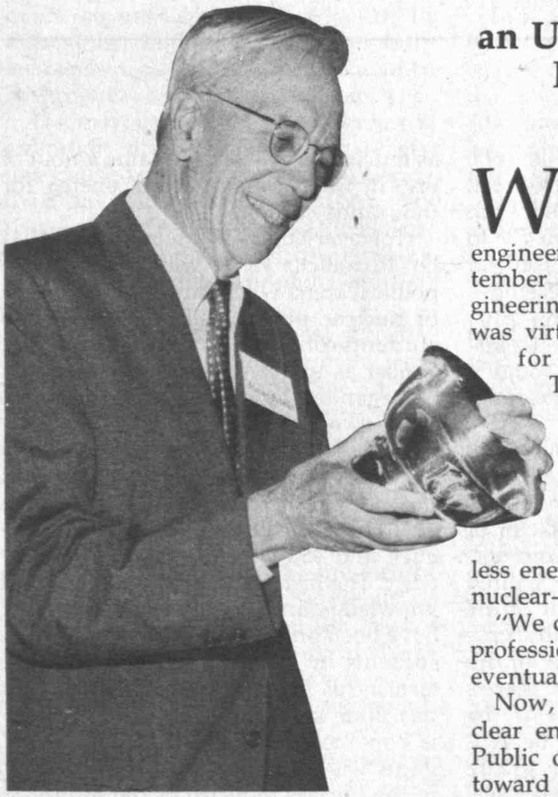
Though many feel lots of frustration, there was no lack of optimism among the nuclear engineering alumni who returned last fall to celebrate the department's first 25 years. Manson Benedict, Ph.D.'35, founding chairman, and Neil E. Todreas, Sc.D.'66, shared a toast (opposite); the department gave Benedict a Revere bowl to proclaim their affection (below); and Nunzio J. Palladino, chairman of the Nuclear Regulatory Commission (left), brought the NRC's congratulations "for your many contributions to the well-being of the nation." (Photos: Atlantic Photo Service, Inc.)



After 30 Years of Teaching an Undying Faith in the Nuclear Option

by Frank Lowenstein

When Manson Benedict walked into his classroom to begin M.I.T.'s first course in nuclear engineering for seven students in September 1952, the field of nuclear engineering was only dimly seen. There was virtually no information available for use in teaching the course. There were no commercial nuclear power plants, almost all of the little that was known about nuclear power was classified, and the future of nuclear engineering was mostly dreams of limitless energy—cheap electricity and even nuclear-powered airplanes.

"We could only guess what kinds of professional work our graduates would eventually do," recalls Benedict.

Now, once again, the future of nuclear engineering is a matter of faith. Public opinion is much less favorable toward nuclear power—a change that has colored nuclear scientists' view of themselves and their profession. "People are much more on the defensive these days," muses Dr. Benedict. "Back in the 1950s—why, everybody felt that it was a sure thing. The world was already convinced that it had to have nuclear energy. Now you really have to preach the nuclear gospel."

The hopes of the early years were epitomized by the First International Conference on the Peaceful Uses of Atomic Energy, to which Manson Benedict was a delegate in Geneva in 1955. "There were people from all over the world—from the Soviet Union and Japan—and everybody was on the best of terms. It was a genuine effort to cooperate and make available to everybody the constructive possibilities of this energy source."

The information shared at the Geneva Conference—much of it declassified by the U.S. since 1952—enriched the study of nuclear engineering. In its wake, the field established itself as a well-defined discipline, nuclear power came into common use, the course offerings at M.I.T. rapidly broadened, and enrollment increased.

Dr. Benedict expects a return of that

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Twenty-five years of nuclear engineering leadership (left to right): Manson Benedict, Ph.D. '35 (1958-71), Elias P. Gyftopoulos, Sc.D.'58 (acting 1968-69), Edward A. Mason, Sc.D.'50 (1971-75), Kent F. Hansen, '53 (acting 1975), Norman C. Rasmussen, Ph.D.'56 (1975-81), and Neil C. Todreas, Sc.D. '66 (1981-).

25 Years of Nuclear Engineering

Continued from page A21

tunities, they said, are "potentially large"; and they proposed $1 million, five-year programs on two of them—design simplifications of conventional fission reactors and a feasibility study for a small, modular high-temperature gas reactor.

Their report, widely regarded as an agenda for the first major contributions of the department during its second quarter-century, was the highlight of six simultaneous afternoon sessions.

"My Children for Life"

The evening was devoted to a tribute—often emotional—to the department's founding head, who turned out to be just 24 hours short of celebrating his 76th birthday. There was a letter of congratulations from George A. Keyworth, science adviser, in behalf of President Reagan.

There was the announcement of a $300,000 fund for the Manson Benedict Fellowship and its first award to graduate student Robert Witt.

And finally there was a tribute from Professor Neil E. Todreas, Sc.D.'66, on behalf of the faculty that he now leads as department head. "The Manson legacy is a faculty of common principles and deep trust. Together we are collegial and frank. Our discussions are searching and intense—but always punctuated at just the appropriate moments with humor and levity sufficient to ensure that we maintain perspective on the issues and, most important, on ourselves."

Responding to the ovation, Benedict recalled a Chinese dinner tendered by Hing-Yan Watt, '69, upon completion of his doctoral thesis. Inside his fortune cookie, said Benedict, was a slip of paper reading, "He who teaches me for a day is my father for life."

It's true, said Manson. "In a very real sense, all of you, my former students, are my children for life."

Manson Benedict

Continued from page A21

confidence; he remains a steadfast believer in the potential of nuclear energy. "The low esteem in which nuclear power is now held in many quarters is a temporary phase. Ten or fifteen years from now we'll be building more nuclear power plants, and we'll be convinced that they're the most reliable, least environmentally harmful, and among the most economic ways of generating electricity."

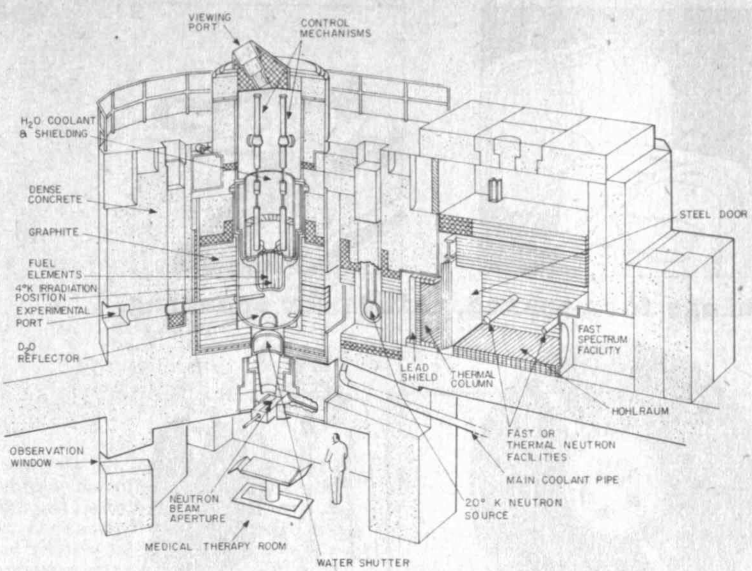
But Benedict also sees dangerous flaws in current policies toward nuclear power research. "Uranium supplies are limited. It's true that the visible uranium supply will last longer than anticipated a few years ago, but in 30 or 40 years we're going to run out, and we're either going to regard present types of nuclear power systems as just a temporary, small contributor to the world's energy sources and give it up, or we're going to have to go to the breeder and reprocessing."

(Only one part in 140 of natural uranium is uranium-235, the isotope used to fuel nuclear reactors. The rest, uranium-238, is largely unused. The breeder reactor converts uranium-238 to plutonium, which can also be used for reactor fuel. Similarly, reprocessing—extracting usable uranium and plutonium from spent reactor fuel—improves the fuel economy of today's nuclear power plants and is essential for the breeder.)

"If we had a breeder, the amount of power which could be produced from the uranium which is now economic to mine would be increased by a factor of 60 or 70. That would make the commercial uranium resources of the United States potentially the equivalent of the energy in all of the economically producible oil all over the world, or all the coal in the United States. But there's more to it than that; because if the breeder is developed it would be economical to use much lower grade uranium, because you can get 60 times as much energy from the same amout of ore. It promises supplies of energy for thousands of years."

However, there is no assurance that Dr. Benedict's views will prevail in the political arena where much of the future of nuclear power will be decided, so students of nuclear engineering face almost as many uncertainties as when he began teaching 35 years ago. That's a bitter-sweet memory:

"I think it's most unfortunate that the technology that's been developed and the people who've been trained are likely to be dispersed and their experience and knowledge lost," says Benedict. The fact that some fraction of that knowledge and experience now at risk have been brought to the nation and its students by Benedict himself does not tarnish his love affair with the field he has done so much to advance. For he is convinced that today's nuclear students will have important roles to play in the nuclear industry of the future.



In 25 years since its completion (1958), the M.I.T. research reactor has been "a key element in establishing M.I.T.'s leadership role in nuclear research and education," says President Paul E. Gray, '54.

Research Reactors: High Science, Low Profile

When plans to build the M.I.T. research reactor were announced 29 years ago, the then-mayor of Cambridge was unimpressed: if M.I.T. was sure the reactor wouldn't harm its students, he wasn't going to worry about the effects on more distant Cambridge residents. Its nearest neighbor, New England Confectionary Co., asked if there would be by-product steam for making candy.

The mayor was right: after 25 years of operation the M.I.T. research reactor has caused Cambridge no problems. (Nor has it produced any steam. The reactor's waste heat—though considerable in amount—is of such low temperature that it's not economic even for space heating.)

But in the reactor's first quarter-century the achievements of its users have made the M.I.T. machine "a vital force in education and research at the Institute and elsewhere in New England," says Manson Benedict, professor emeritus who was the first head of M.I.T.'s Nuclear Engineering Department (*see above*). It's produced a prodigious river of neutrons, the neutral atomic particles that are essential for research on atomic structure, the creation of exotic isotopes, and trace analyses. It's been an unparalleled training ground for M.I.T. students preparing to enter the nuclear industry. And the reactor has been a test bed for materials and control systems research—including current studies of fault-tolerant computer controls with the Draper Laboratory—for commercial power reactors.

It is, in short, a star among the nation's 111 operating research reactors. Only one other U.S. university reactor, the 10-megawatt machine at the University of Missouri, produces such a copious flow of neutrons.

In all, according to Benedict's data reported at an international symposium at M.I.T. last fall, there are 327 research reactors now in operation in the world. At 5 megawatts the M.I.T. reactor is large among research reactors, and it's touted as "one of the most capable research reactors at any university." Like all the others it's small, safe, and seldom in the news—which suits their operators well enough most of the time.

But right now some visibility is needed. At least in the U.S., research reactors are an endangered species, too little appreciated and supported by those outside the immediate communities of scientists they serve, says Otto K. Harling, director of the M.I.T. Reactor. Funding is simply too low.

An example of the problem: the M.I.T. Reactor now operates only 95 hours a week, and many of its capabilities are not being tapped—not because there are no problems for researchers to bring it but because funding is insufficient. Hence the spotlight that Harling and his associates hoped to focus as hosts of an international celebration of the reactor's 25th anniversary.

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Princeton, N.J., area at the time of this writing. . . . **Kenneth W. Miller,** S.M.'82, stopped briefly at M.I.T. in October and had lunch with Jane Morse. He is enjoying his job as product engineering manager at Duracell and gets to travel quite frequently to Boston, Atlanta, and New York City. He often sees Chris and **Rick Bullen,** S.M.'82, while in New York and reports they are doing fine. His wife, Joan is pregnant again, and they are looking forward to a second child.—Jane Morse, Program Manager, Room E52-533, M.I.T., Cambridge, MA 02139

XVIII

Mathematics

M.I.T. is one of 22 institutions whose mathematics departments are receiving support for the purchase of computing equipment for scientific research under a $850,000 National Science Foundation program. The Institute's share, $33,000, will provide an advanced computer graphic work station.

Paul Ruel Young, Ph.D.'63, former professor of computer science and mathematics at Purdue University, became professor and chairman of the Department of Computer Science in the College of Arts and Sciences at the University of Washington, Seattle, last September 1.

XX

Nutrition and Food Science

Four members of the faculty have received grants from M.I.T. under the microbiology research program funded by W.R. Grace & Co.: **Arthur T. DeMain** (enzymatic synthesis of specific dipeptides), **Alexander M. Klibanov** (enzymatic separation of hydroxy compounds), **Anthony J. Sinskey** (corynebacterium glutamium), and **Daniel I.C. Wang,** '59 (bioreactor operations).

XXII

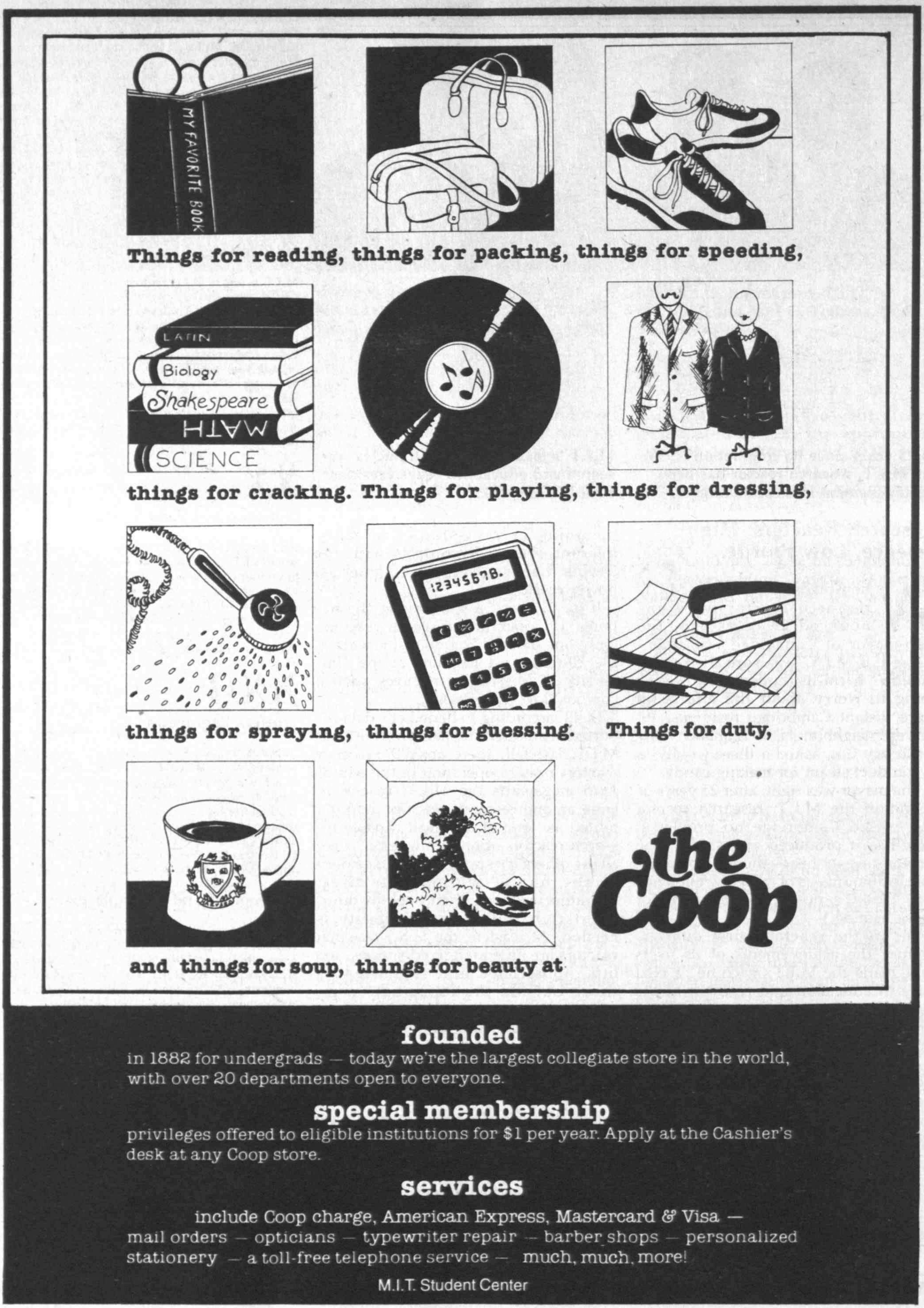
Nuclear Engineering

Tatswiro Suzuki, S.M.'79, reports, "I am now working at the International Energy Forum (IEF), which is a private policy research institute in Tokyo. My responsibility is to support administrative work of the forum and to work on sponsored/self-financed research projects, mainly in nuclear policy issues. Currently, I am engaged in nonproliferation policy issues and re-evaluation of FBR development strategy for Japan."

Technology and Policy Program

A listing of new jobs for several alumni/ae have recently come into the Technology and Policy Program office: **Jean Tilly,** S.M.'83, and **Sudhakar Kesavan,** S.M.'83, at ICF, Washington, D.C.; **John Newman,** S.M.'82, with the Office of Technology Assessment, Washington, D.C.; **Bill Ryan,** S.M.'83, at the Massachusetts Public Interest Research Group (MassPIRG) working on hazardous waste issues; **Carol Eberhard,** S.M.'82, with the Congressional Research Service of the Library of Congress; **Jeanne Briskin,** S.M.'83, in the Office of Policy Analysis at the Environmental Protection Agency; **Ron Adams,** S.M.'83, with Aerospace Systems, Inc., Burlington, Mass.; **David Chia,** S.M.'83, with Ketron, Inc., Cambridge, Mass.; **David Kagan,** S.M.'80, with the U.S. Synthetic Fuels Corp., Washington, D.C.; and **K. Sarvadevabhatla,** S.M.'80, with A.F. Ferguson and Co., Bombay.

Also, **Jim Spall,** S.M.'81, has completed his Ph.D. at the University of Virginia and is now a member of the permanent research staff at the Johns Hopkins Applied Physics Laboratory.—Professor Richard de Neufville, Chairman, Technology and Policy Program, Room 1-138, M.I.T., Cambridge, MA 02139


MY FAVORITE BOOK
Things for reading, things for packing, things for speeding,
LATIN
Biology
Shakespeare
MATH
SCIENCE
things for cracking. Things for playing, things for dressing,
12345678.
things for spraying, things for guessing. Things for duty,
and things for soup, things for beauty at
the Coop
founded
in 1882 for undergrads — today we're the largest collegiate store in the world, with over 20 departments open to everyone.
special membership
privileges offered to eligible institutions for $1 per year. Apply at the Cashier's desk at any Coop store.
services
include Coop charge, American Express, Mastercard & Visa — mail orders — opticians — typewriter repair — barber shops — personalized stationery — a toll-free telephone service — much, much, more!
M.I.T. Student Center

13

After an unusually hot, dry summer and fall it is time to get ready for winter (at this writing). One (so-called) expert I know says it is going to be cold and snowy. Let it snow! My wood is stacked in my garage, my freezer is full (much of it grown in my garden this summer), and I can keep busy with needlework projects and reading.

There were three members of 1913 present at Technology Day to celebrate their 70th reunion: **Allen Brewer**, **Warren Glancy**, and **Walter Muther**. Allen's wife Maurine also joined in the festivities. Allen wrote that he is now anticipating the 75th reunion. Warren commented on the gift to the Institute and his enjoyment of the luncheon. I think Warren deserves a medal for his yearly attendance at Technology Day luncheons. The gift of the Class of 1913 was announced, for which Walt Muther took a bow.

The Alumni Office notified us of the death of **Raymond B. Haynes** on September 15, 1982. His daughter, Elizabeth sent no other details. . . . **Louis C. Rosenberg** died on June 9, 1983. He had been living at the Mountain View Convalescent Circle in Oregon City for some years. He was well known in art circles for his etchings and architectural drawings, especially in Europe where he had spent much of his professional life. Happy holidays.—**Rosalind R. Capen,** Assistant Secretary and Treasurer, 7 Brackett Pt. Rd., Biddeford, ME 04005

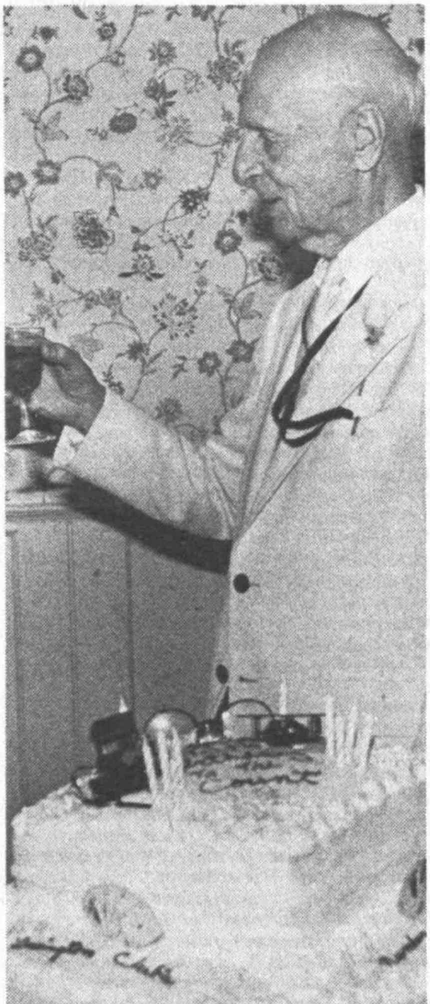
14 70th Reunion

Though a formal reunion hasn't been planned for our 70th, the Alumni Association will welcome those of us who come to Cambridge for Technology Day this June. Plans for it will be announced soon. Housing accommodations will be available at McCormick Hall for a nominal fee. We could have seats together for Tech Night at the Pops and at the Alumni Luncheon, and could have a meal by ourselves either on campus or at a restaurant near the Institute. I'm sure that those of us who came to our 65th would like to come again this year, and I hope that some who didn't make it then can be with us this time. Word from you would be welcome.—**Charles H. Chatfield**, Secretary, 177 Steele, Rd., West Hartford, CT 06119

16

Thank you very much for your response to our plea for news. **Dave Comiskey** writes, "As 1983 draws to a close dates become larger. In my case age is 89, wedding 60, class 67. I have lost so many good friends in the last few years—one of the best was Ralph. I do try to keep up with grandchildren's weddings, just recently went to Manchester, N.H. for one. Grace and I go for short auto rides daily to shop and to visit local friends. I still am a member of the Needham senior council for the elderly, meeting weekly. The Retired Men's Club of Needham

Dina Coleman: 90 Years With Good Genes



On the occasion of his 90th birthday the *Lexington* (Ky.) *Herald-Leader* asked Caruthers "Dina" Coleman '16:

How does life feel the day you turn 90?

It's no different. It's just another day. I've reached that age when I can remember what I was doing in 1897, but I can't remember what I had for lunch yesterday.

What's the secret of long life?

One thing is to have good genes.

Then, I don't ever worry about something I can't change—business, politics or whatever. It's no strain to concentrate on what you can do. But trying to stay awake at night to solve an impossible problem, or one that's beyond your ability, is what ages people.

You were born in 1893. Do you think you've lived in the best of times?

Up until shortly after the Civil War, except for the steam engine—which produced steamboats, steam trains and all that—there'd been no change in transportation since the development of the wheel. People got around in 1843 about like they'd gotten around in 1843 B.C.

Then there was Edison's development of electricity. That just broke the whole world apart. In my lifetime, there's been the development of radio, TV, computers, airplanes, all that. None of that would have been possible without electricity.

I keep thinking about the future, my children, the world they're going to live in. It's going to be so entirely different than the world we're living in right now, you can't really dream of what it's going to be.

meets two times monthly with attendance of about 250, out of 350 listed men. This is a high percentage. Very few of the 250 need help to move about. So exercise keeps me going."

We were pleased to hear from **John Fairfield**. He writes, "Living alone has drawbacks (as in the cooking department) but advantages in some details. One is free to experiment on household arrangement and equipment, like the story of the man who found a place to put his feet—he nailed his slippers to the wall. I found (but have now misplaced) a quotation I intended for **Dina Coleman**. General Jackson (the hero of the battle of New Orleans) received a consignment of Kentucky volunteers and commented that he had never found a Kentucky soldier who came without his own gun, a bottle of whiskey, and his chewing tobacco. I still can't resist the pleasure of seeing things grow and bloom, and like all farmers and gardeners grousing about how the weather and bugs don't cooperate. That and reading and friends. Keep up your reminding us of our duty to the class."

And from **Will Wylde:** "I have just received your letter and am glad to respond with a brief summary of recent doings in my uneventful but extremely lucky and happy life. Donnie and I moved into a retirement home last December. We hated to sell her home in Anna Maria Island near Bradenton, Fla., but as my 90th birthday was approaching I felt I should be in a place with full security, a health center, dining facilities, and so on. This is also a place with many interesting activities. I am lucky to still be quite active physically fit, I must confess, mentally quite slow and forgetful.

Donnie and I go up north every summer principally to attend the annual Wylde family reunion in North Adams, Mass., which is always held in August and thus does not coincide with reunion time at Tech. However, if I make it and am in a travelling condition, in June 1986, we sure will be there for the 70th."

Dina Coleman sent us a brief note and enclosed several interesting newspaper clippings about his recent activities. We quote in part from the *Lexington* (Ky.) *Herald-Leader*: "Caruthers A. Coleman, nicknamed 'Count,' is one of Central Kentucky's most prominent business executives, civic leaders and patrons of the arts. He turned 90 years old on August 19, and continues to be sharp of mind and indomitable of wit. He lives on Deepwood Drive with his wife, Isadora. He has received nearly every major civic honor in Lexington since coming here after World War I.

Coleman has been a builder, realtor, and brick manufacturer, and has influenced business, education, and the arts. For 22 years, he led the growth of the Lexington Philharmonic as its chief executive officer. He has served on the local board of education has been a president of the local chamber of commerce." (see box, p. B1)

Walter J. Wolfe, 88, of Brandenton, Fla. died on August 18, 1983. He was buried in Arlington National Cemetery. A retired army colonel, he leaves his wife, Grace; two sons, Colonel Walter Wolfe of Alexandria, Va., and Dr. James Wolfe of Hattiesburgh, Miss.; a sister, Elise Dike of Charlton, Mass.; seven grandchildren; and a great-granchild. . . . Dorothy Haines sends us notice: "My cousin **Elmer B. Haines** passed away in Tampa, Fla. on August 25. 1982. He was 90 years old and had kept house himself until the last month of his life.

Keep eating, drinking, walking, breathing, everything in moderation, and yes, of course, keep writing.—**Bob O'Brien,** Acting Secretary, H.E. Fletcher Co., Groton Rd., West Chelmsford, MA 01863

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Edward Payne died on September 4, 1983 in a nursing home in the Boston area, where he had been almost two years. He is survived by his wife Elizabeth, who used to come to class reunions with him, and by a daughter in New York. He is also survived by a son Roger who is an expert on whales and lives in Lincoln, Mass. Christine and I had the pleasure of meeting Roger and hearing him give a talk on whales at the Academy of Natural Sciences in Philadelphia a few years ago.—**Walter J. Beadle,** Secretary, Kendal at Longwood, Box 217, Kennett Square, PA 19348

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After our most successful 50th reunion in 1968, we started mini reunions in the fall and spring of the intervening years to the five-year get-togethers. As time went on and our members decreased, we augmented these by including the classes who were at M.I.T. while we were undergraduates. Two years ago we expanded this group to all classes who already have had their 50th reunion, and the Cardinal and Gray Society was born. It has grown to the extent that about 150 alumni, spouses, and widows were together, as they will be on Sunday, October 16, at Endicott House to have lunch, enjoy a talk by an M.I.T. professor, and indulge in a pleasant afternoon with classmates. The speaker for this meeting is Professor Ernest Cravalho, associate director of the Harvard-M.I.T. Division of Health Services. I only wish all of you could be with us. Out of acorns such trees grow.

In the Sunday September 25, *New York Times*, was the following letter to the editor from **Herb Larner.** "If Thomas Carlyle was right when he wrote "Silence is the element whereby great things fashion themselves" what nonsense for the American Civil Liberties Union to create such a fuss about one minute of silence in the schools of New Jersey."

We had the pleasure of having lunch with "Biscuit" (Mrs. **S.H.**) **Chamberlain** who is in good health. She is busy collating Sam's many drawings and soon will have this material ready for a new book using this collection.

We now have more information about **Jim Todd** who passed away on March 23, 1983. During World War I he served his country as a navy officer. A former member of the Kiwanis Club of Nashville, he was retired vice-president of Harvey's Department Store. As a final and thoughtful gesture to mankind, he donated his body to the Vanderbilt School of Medicine.—**Max Seltzer,** Secretary, 1443 Beacon St., Brookline, MA 02146; **Leonard I. Levine,** Assistant Secretary, 519 Washington St., Brookline, MA 02146

19 65th Reunion

At this writing we have only good news. Through the courtesy of Marion Lockhart, daughter of **Arthur Kenison** we are informed of a 60-year wedding anniversary of her parents, Arthur and Maybella. The party was held on September 29 at Kingston, Mass. Arthur is an Insurance Broker involved with the New England Mutual Life Insurance Co. of which we understand he is listed in their Hall of Fame. Thanks to Marion Lockhart and congratulations to Arthur and Maybella.

When you read these notes in January 1984, you will be within six months of the important event of the Class of 1919, their 65th Reunion. As reported earlier, 23 classmates and 11 wives and guests indicated that they would attend if able to do so at the time. We sincerely hope they do and that they may be joined by others who didn't happen to respond to the class poll. Now for a few reunion remarks.

The reunion activities start on June 7 and end on June 10. Information about registration and the schedule of general events will be sent to you well in advance. Our class chose to quarter at the Hyatt Regency in Cambridge on the Charles River near the Institute. There we can readily meet with each other in comfortable surroundings. **Don Way** and his wife Barbara will be there to greet you with help from representatives of the Alumni Association. We understand the McCormick dorm will be made available by the Institute to any wanting to be on campus. Parking is available to any who may drive, and shuttle bus for others. As the time draws near attendees must plan at least three weeks in advance for hotel reservations. These remarks are intended to alert you to implementing your plans to attend. Your reunion committee will be sending you more complete and detailed information. See you at our 65th.—**W. O. Langille,** Secretary, Box 144, Gladstone, NJ 07934

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Last month breaks a record. I have heard from no less than two classmates. **Buzz Burroughs** phoned, and by his voice I judge him to be the same old Buzz. Playing golf all summer and curling all winter. More power to him!

Buck Clark wrote to say that he and Mary had been up to Brooksville, Maine, to their summer cottage and had supervised the marriage of two of their grandchildren. Come to think of it, your secretary is expecting to become a great-grandparent well before these notes reach you. He is crowing over Perk who has no less than nine grandchildren but has not been blessed, so far, by that happy event.

Do write me.—**Harold Bugbee,** Secretary, 21 Everall Rd., Winchester, MA 01890

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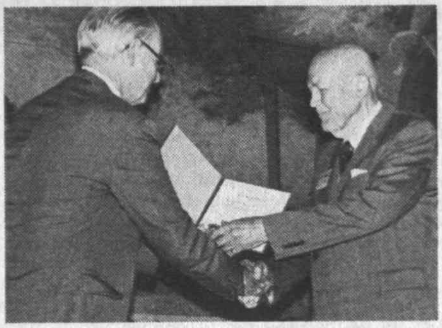
The fall 1983 issue of *The Lamp*, the publication of Exxon Corp. had a most interesting article on the tugboat *Exxon Maine*, built in 1982 by the Jackobson Shipyard in Oyster Bay. An unusual feature to your secretary was the elevating wheelhouse which can be raised where desirable to get a better view of barges being towed. In a phone call to **Irving Jakobson,** we learned that this feature has been available for years and was used successfully on the Erie Canal to keep a close watch on the tow. Jake tells me the *Exxon Maine* is loaded to the gills with electronic gear. Jake himself is no longer active in running the shipyard but his nephew is in full charge.

A good letter from **Whitney Wetherell** in mid-September said life on Cape Cod was no longer so hectic, now that Labor Day had come and gone. He reported that **Sam Lunden** had recently returned to his summer cottage following a Caribbean cruise. Earlier in the summer Whit had lunch with Sam and Leila Lunden and in the afternoon had a ride in Sam's boat down the Bass River and out into Natucket Sound. Whit reported that **Don McGuire** was now back in Harwich after a long stay with family in Maine. Don and Whit attended the M.I.T. club picnic of recent date.

The class of 1921 had another mini-reunion at the National Alumni Affairs Conference on September 23 and 24. It had the largest number of attendees of any mini-reunion since our 60th back in 1981. Attending for the Saturday Awards Luncheon were Maxine and **Cac Clarke, Frank Whelan, Don Morse, Leo Pelkus, Howard Forbes, Sam Lunden, Whitney Wetherell,** and **Sumner Hayward**. Your secretary was honored in being named as a recipient of the Harold Lobdell Distinguished Service Award. The actual award will be presented at a meeting of the M.I.T. Club of Northern New Jersey. The conference had an excellent program with fine lectures, addresses and presentations by undergraduates in the UROP program.

Howard Forbes was a new attendee at our class gatherings and I learned he had worked many years for M.I.T. on U.S. government support contracts. . . . **Leo Pelkus** still goes to his office and Sam Lunden is another in our class still doing consulting work. . . .

Following the Saturday luncheon, **Cac Clarke** and **Don Morse,** our reunion chairman, asked if the rest of the 1921 group would confer for a while on our 65th reunion plans for 1986. M.I.T.'s Endicott House in Dedham has been reserved for our reunion and meals and rooms for staying overnight will be available for all those attending. Other classes have had reunions at Endicott House and have been most enthusiastic about the accommodations and meals. It was the consensus of the group dis-



The 1983 Bronze Beaver to Horace W. McCurdy, '22 (right), from Robert W. Mann, '50, president of the Alumni Association. " 'Mac' McCurdy, 'Mr. M.I.T. of the Puget Sound,' has generously endowed and staunchly supported M.I.T. crew, an M.I.T. varsity sport which he founded and which he captained in his senior year. . . . For a lifetime of creative, responsible involvement with M.I.T. and the Alumni Association." ***(Photo: Scott Globus, '84)***

cussing reunion plans that no strenuous program be set up for our 65th. It was felt preferable to spend most of the time at Endicott House for reminiscenses and talk among classmates.—**Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, NJ 07450; **Josiah D. Crosby,** Assistant Secretary, 3310 Sheffield Cir., Sarasota, FL 33579; **Samuel E. Lunden,** Assistant Secretary, 1149 S. Broadway, Suite B-800, Los Angeles, CA 90015

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A half-page spread in the *Hallandale* (Fla.) *Digest* of September 15, 1983, was headlined "Colonel **Ray C. Burrus**—City Editor." This biographical summary of Ray's long and meaningful career is illustrated by a large picture of Ray and Mrs. Burrus (married 60 years). His career spanned ten years with Florida Power and Light, active duty in World War II principally related to aircraft production in this country and then aircraft disbandment in Europe, and 25 years with Electric Bond and Share. After retirement in 1965 to Hallandale, he immediately became involved in a broad range of civic activities, including founding of Hallandale Chapter of A.A.R.P., director of the Chamber of Commerce and work with the Hallandale Historical Society. The reporter concluded the interview by asking, "How do you remember everything so well?"; Ray responded, "My mind is like a sponge—I just sit back and absorb."

Horace W. McCurdy, crew's principal benefactor at M.I.T., has added $200,000 to the H. W. McCurdy Endowment for Crew, bringing the total to $400,000. With that kind of financial support, adequate turnout by the undergraduates, and proper coaching, perhaps we will soon see M.I.T. becoming an Eastern rowing power. On September 24, at the National Alumni Conference in Cambridge, Mac was awarded the Bronze Beaver, an honor long overdue.

A paper by **Bill Elmer**, "The Optics of Reflectors for Illumination," was selected as one of three papers to receive the Production and Application of Light Committee Prize Paper Awards by the Industry Applications Society. A certificate and a check were formally presented to Bill in October at the meeting in Mexico City.

A letter from his widow tells of the death of **J. Gordon Campbell** on November 9, 1982. He was a Phi Beta Kappa graduate of Princeton before coming to M.I.T. for his B.S. degree with our class. He was a member of Delta Upsilon fraternity.—**Yardley Chittick**, Secretary, Box 390, Ossipee, NH 03864

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Many thanks to **Jerry Fitzgerald** for writing the November/December class column while your secretary-treassurer was in Indiana on family business. Summer heat, humidity, and drought were dreadful, and much of the corn crop was lost.

As a consequence of offers made in connection with the 60th reunion and subsequently by letter and in the October notes, 14 copies of the *Great History* were sold to class members and ten copies were given to widows. Since a couple of dozen copies remain available, the offers still stand, $5 for class members, widows gratis.

Al Pyle has moved to 110 W. 30 St., Wilmington, DE 19802, to be near an ill sister. . . . Your secretary-treasurer attended the National Alumni Conference held at the Institute September 23-24. . . . A letter from **Doc Smith** and an accompanying clipping tell of the death of his wife, Eleanor, on June 28, 1983, at Lakeside Hospital, Shaker Heights, Ohio. For many years she had helped make doll dresses for the annual Christmas doll giveaway to needy children, sponsored by the Salvation Army. She had been a member of the women's committee of Children's Services. She was a founder of the Shaker Book Club in the mid-1930s. She was a native of Lowell, Mass.

We have only recently learned of the death of Colonel **John J. Breen** on June 6, 1974. As a lieutenant in the Ordnance Department, U.S. Army, he studied courses in mechanical engineering with our class. We have no information about his subsequent career.—**Richard H. Frazier**, Secretary-Treasurer, 7 Summit Ave., Winchester, MA 01890

24 60th Reunion

"M.I.T. Benefactor Billard Dies" was the *Tech Talk* headline that shocked your secretary October 6, 1983. **Gordon Y. Billard** died unexpectedly September 18, 1983. He was awarded his S.B. in business and engineering administration, having prepared at the University of Cincinnati. He joined several New York Stock Exchange firms as an investment manager, becoming a partner in J.R. Williston and Co., which granted him leave of absence in World War Two as a lieutenant commander in the Navy, resuming active partnership in 1945. He was a financial consultant, engineer, economist, investment banker, and corporate director of many companies.

Gordon was an active fellow of the New York Academy of Science serving as treasurer, director, and chairman of its financial committee, and only the second person to receive the academy gold membership card since its founding in 1817. He was class estate secretary and 60th reunion gift chairman. A major financial supporter of the Sloan School of Management shortly before his death, he had endowed the Gordon Y. Billard Professorship in Management and Economics chair. It is reported that M.I.T. is the residuary beneficiary of Gordon's estate, the gifts from which are believed to honor him as the largest individual donor to the Sloan School since the Alfred P. Sloan gifts founded the school. He had also endowed the Gordon Y. Billard Fund in memory of his mother, to provide an annual award to a faculty member or employee in recognition of special services to the Institute.

In October, you should have received a letter from Hugh Darden, Institute Vice-President for Resources Development, acknowledging the timely acceptance by **Phil Blanchard** of the office of class estate secretary. Your secretary, when confirming this action by telephone, learned from Phil that, by chance, he and Besse thoroughly enjoyed a week with Liz and Jim Killian, '26, at the Spaulding Inn Club, Whitefield, N.H.

The 60th Reunion Committee held a luncheon meeting October 20, with **Ray Lehrer** as the always gracious host at the Algonquin Club, Boston. Plans were made to settle our central location, for which attendance cards will be mailed soon. Please submit "wants" and "don't wants" for those coming rare days next June. Write or call me at (617) 232-0634. AT&T needs your support.—Co-secretaries: **Russ Ambach**, 216 St. Paul St., Brookline, MA 02146; **Herbert R. Stewart**, 8 Pilgrim Rd., Waban, MA 02168

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Jim Howard reports that he and **Ed McLaughlin** represented the class at the National Alumni Conference in Cambridge in September. Jim noted further that our honorary classmate, **Joe Martori**, will be working with us on planning for the 60th reunion.

A letter from **Sam Spiker** tells us that during the summer when in Portsmouth, N.H. he called Lil (Mrs. **Garvin**) **Drew**, and arranged to go to New Castle to see her. He found her to be fine and full of plenty of vim and vigor. For many years she and Garvin came from California to spend the summer at New Castle where they had several cottages on a practically private tidal pond circled about 250 degrees by woods with no houses and looking out to a wide view of Portsmouth harbor. Sam urged Lil to come to our 60th reunion and we hope she will decide to join us.

A note to **Ben Oxnard** telling him of my hospitalization brought a response in which he says he is running out of spare parts the same as his 18-year-old auto. Some parts have been replaced and all he needs now is a wig to be newly built from head to foot.

A few months ago the passing of **Beverly Hubbard** was reported. Elizabeth A. Bagnall '74, the 1982-83 president of the M.I.T. Club of Princeton has been so thoughtful as to provide some information regarding Bev. His passing followed a short illness. After graduation he remained at M.I.T. on the teaching staff for several years. For several years he worked for the Navy in Communications, traveling to several parts of the world including Indonesia. He had worked for the Roebling Wire Co. in Trenton as well. Bev was one of the founding members of the Princeton M.I.T. Club and had served continuously on the board from the club's inception. He was a member of the National Acoustical Society. Bev is survived by his daughter, Mrs. Marcella Davidson, and two granddaughters.—**F. Leroy (Doc) Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

Wearing the official Class of 1928 cardinal shawl, Shirley Picardi (right), secretary of the Alumni Association, accepts a certificate of honorary membership in the class. Bestowing this honor are Walter Smith, class secretary, and Florence Jope Smith at their 55th Reunion.

26

Following the sad news of the deaths of several of the most prominent members of our class in the previous issue of the *Review* there has been a period of welcome relief from such events, but also, unfortunately, from all other news from our classmates. We heard indirectly from **John Longyear** through a letter he wrote to the Alumni Association in late August.

Peter Bellaschi called recently concerning an appointment he wished to arrange with the Lahey Clinic Medical Center for a conference on a potential operation, although his general vigor is obviously as great as ever as witnessed by the itinerary of his travels from Portland, Ore. to Baltimore to Washington and possibly to Boston in early October. We hope to see Peter at the time of his Boston visit.

A note from **George Makaroff** tells of how upon his arrival from Constantinople as a greenhorn in the U.S. he sat next to **George Leness** in a senior class and carries to this day fond memories of his massive charm and friendliness. . . . **Austin Kelly** gave a lecture at M.I.T. on "The Love of the Book" at an exhibition of the Kelly Collection of Rare Books on October 12 in his capacity as curator of Rare Books, M.I.T. Libraries.—**William Meehan**, Secretary, 191 Dorset Rd., Waban, MA 02168

27

Sequel from last month's issue (**Bud Cole** to **Sid Blandford**): "I also attended U. of Colorado in 1926-27. This would have been my senior year at M.I.T., so I went back the following year to get my degree. My year at Colorado was unplanned and unexpected. Enroute to vacation at Stapps Lake, I had to lay over in Boulder for a bus. When I learned that it was the site of the University, I headed for the campus. One look was all I needed. I sold my Dad on the idea of attending what looked to me as the choicest spot this side of heaven. It was a wonderful year and what every Tech man needed.

"I met Helen, my one and only wife, at Boulder. She taught school while I was back at M.I.T. finishing up my degree. We were married in Boulder, then left immediately for Fullerton, Calif., where I had a job with Union Oil Co. California has been our home ever since. Although these were depression times, I changed jobs often and had more jobs at one time than one individual was entitled.

"The only solution to my employment problem was to go into business for myself. I started a rubber and plastics company from scratch. It was the right time and at the right place—Palo Alto. This area has become famous for its Silicon Valley. Hewlett-Packard, Varian, Ampex, and a host of others were all one-to-two-men operations when Cole Rubber and Plastics came into being. Success was the simple matter of rendering a service and filling a need. Silicone rubber was a new development and had many applications in the medical field. It left us with the only supplier in the area. We made heart valves and a line of products that you would appreciate as a member of the medical profession.

"I sold my business in 1970 and have retired to full-time golf and local activities. Our son, daughter, and four grandchildren live nearby.

"You have no doubt noticed there is never a lack of news in the *Tech Review* '27 notes. Again let me tell you how pleased I am to have heard from you. Your experiences at U. of Colorado brought back a lot of pleasant memories and it is very interesting to hear of your experiences in the medical profession."

Dick Cheney also wrote to Bud: "Enjoying as I do the monthly class notes in the *Review* which you and your fellow secretaries so ably produce, my conscience tells me that the least I can do is respond. I have resigned from the two county and city commissions which I chaired for eight or nine years, and my consulting practice is now confined to advising the chancellor's office at the U. of California in Santa Barbara on relations with the business community. A call to **Bud Fisher** opened communications with the industry-relations department at M.I.T. which has been most helpful.

"I think we would all agree that at this stage in our experience, the most important thing is to plan for good things to look forward to. Ours has become a four-or five-week sojourn in Switzerland each year. We rent a small condominium apartment at about the 4,500-foot level a few miles east of Montreux with a gorgeous alpine view. Our Swiss holiday pass (very reasonable) takes us every where, first class, by rail, post-bus, or lake steamer. We explore remote valleys with their ancient stone villages, sleep in old palaces (now country inns), enjoy magnificent alpine scenery from mountaintop villages, and have even climbed several 10,000-foot peaks with a little help from finiculars and aerial cable cars. All this is very reasonable as we stay out of the big cities. We recommend it highly!"

Larry Grew has reported that **Harry S. Falkoff** of Branford, Conn., died in 1982. He was a public accountant in the town for many years, and was a VI-A electrical engineer.—**Joseph C. Burley**, Secretary, 5 Hutchinson St., Milton, MA 02186; **Lawrence B. Grew**, Associate Secretary, 21 Yowago Ave., Branford, CT 06405; **Prentiss I. Cole**, Associate Secretary, 2150 Webster St., Palo Alto, CA 94301

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Now that we have entered into a fresh new year, we wish all of you good health and success with your plans for the days ahead.

One never knows what event might be triggered by a reunion. Some we may never hear about but here are two that did surface, and this first one with full exposure. When **Ernie Knight** received his copy of the colorful 55th reunion group picture he was so impressed as to write a two-page letter to **George Chatfield** who had been in charge of the class picture project. In writing to George, Ernie was intrigued by the name of George's town, Rindge, N.H. Since Ernie is a compulsive historian (especially where small towns are concerned), he did some research on Rindge and this was reported in his letter to George. In early colonial days Rindge had been one of the "defense towns" designed to protect the Boston area from French and Indian raids. This letter of Ernie's then inspired George to write and publish an editorial on such defense towns in his (George's) own newspaper, *The Montachusett Review* (circulation: 48,000).

Then the second reunion consequence story: Marjorie (Mrs. **John A.) Carvalho**, who attended the reunion, discovered that our classmate **Ernest Mason** (who did not attend) was one of her high school classmates and long missing from the high school records. After some detective work Marjorie located and wrote to Ernest. She received this in his reply: "I am married, have two children and twin grandchildren, a boy and girl, aged 9. I have lived a happy and uneventful life. Like the Timex watch, I am still ticking and expect to continue doing so into the next century."

Bob Harris is confined to a nursing home with Alzheimer's syndrome. However, wife Helen did attend part of the reunion activities and brought some of the spirit to Bob's room by mounting the group picture on his bulletin board. . . . **Paul Ruch** was particularly pleased with the 55th reunion book, *Thoughts and Sentiments*, and wrote to tell us so. . . . A cheerful and pleasant letter from Mary (Mrs. **John B.) Russell** tells us that she enjoyed receiving the various reunion mementos. She missed the letters that had come frequently from **Fritz Rutherford** but she does stay in touch with Verna and **Carroll Smith**.

A note from Olive and **Newt Foster** called to our attention that four other members of **Gabe Disario**'s family graduated from M.I.T. They are: his daughter, Caroline Disario Chihoski '56, her husband, Russell Chihoski '54, Gabe's granddaughter, Helen Ann Chihoski '79 and, sadly, his grandson, Russell Francis Chihoski '83, who died in a mountain hike accident only a few months prior to graduation.. . . **Lazare Gelin** complains that five years is too long to wait between '28 gatherings especially at this stage in life. He proposes an annual mini-reunion. We must remind all of you that this is very easy to accomplish. You need only to attend the annual Technology Day exercises in Cambridge when each class assembles at assigned tables for the luncheon. There is always a good lively '28 group, and the occasion could be expanded to something more ambitious.

It is with deep regret that we report the deaths of three classmates. **George E. Calef** died August 31, 1983. We were informed of this by telephone and in a note from his brother, Edward Flanagan. George graduated in Course X, chemical engineering, and prior to retirement, was a chemist for the U.S. Government Quartermaster Corps in Guam, Alaska, and Natick, Mass. He was unmarried. . . . **Komnenus M. Soukaris** died June 26, 1983 in Miami, Fla., following a long illness. Komnenus graduated in Course VI, electrical engineering, then studied law at the University of Miami Law School where he received his juris doctor degree. He was a practicing attorney. Our record indicates that he was unmarried.. . . **Robert S. Woodbury** died September 18, 1983. Bob graduated in Course IX-C, mathematics, then later received a master's degree in the history of science and learning from Harvard University. For most of his career he was professor of history of science and technology at M.I.T. On various occasions he served as visiting professor or guest lecturer both in the U.S. and abroad. As commander in the U.S. Naval Reserve, he was awarded the Legion of Merit. Besides wife Constance, he leaves four sons and a daughter. . . . To the families of these classmates we express our heartfelt sympathy—**Walter J. Smith**, Secretary, 37 Dix St., Winchester, MA 01890

29 55th Reunion

Bill Baumrucker of Marblehead, Mass., writes, "Sorry to have missed Technology Day this year. It just happened that our 50th wedding anniversary fell on the same day, and Doris and I felt that such an event should take precedence over all other ac-

tivities. During the month of May, we went to China again—way out West, about 2,100 miles West of Peking. Fascinating Moslem country. It was quite different from eastern China. Beyond the Gobi desert, there is still desert but it is surrounded by snowcapped mountains. We had a brief but most pleasant visit again with our classmate, **Yee Chung Fox** and his son Sung-Sang in Canton. He hopes to join us for our 55th at Chatham Bars Inn. Thanks again for your usual birthday greetings. Best regards to all. . . . Just for pleasure **Anthony Standen** of South Kent, Conn. is still teaching fourth grade math in the local school. Recently he wrote a book, an outline of antiastrology. Unfortunately, his publisher folded, and if any of you are interested in a copy, please get in touch with Stan. . . . **Murry Brimberg** of Silver Spring, Md. writes, "Your birthday greetings are always welcome and sincerely appreciated. Our activities during the past year included a trip to Spain and Florida and a side trip to New York to visit our family. We are looking forward to the 55th reunion next year and hope to see all friends again. Regards to all."

I received a distressed note from **James C. Coe** of Phoenix, Ariz., a graduate student from the University of Nebraska, stating that in 1980 he and his wife donated 1,300 South African gold coins, worth close to $900,000, to his alma mater for the betterment of the engineering school's facilities. After all the publicity over the gift, the student senate voted almost unanimously to urge the college authorities not to accept the gift on the grounds that the gold was stolen from the natives, that minors work for starvation wages, and that slave labor was used mining the gold, etc. He says, "All the South African government's supposed wrong doings were piled on my shoulders." He claims anonymous callers threatened his life as well as that of his wife's; threatened to burn his house, etc. He says that out of fear he hired guards to watch the house and decided not to make any more donations to the college. . . . **Charles J. Miers** of Windham, N.H., who graduated from Somerville High School with your secretary, and **Bob Pride** is head of a family roofing business started in 1857. . . . **Nathan (Nate) Promisel** of Silver Springs, Md. writes, "I am a rare contributor to the '29 news but read with nostalgia—and often with sorrow—about my classmates. On the whole, I have been quite fortunate—some "senior citizen" illnesses but still very active professionally in national and international consulting on materials and resource problems and policy. Also, it has been stimulating in these senior years (maybe because of them) to receive national professional awards and distinguished lectureships. M.I.T. prepares one well, and I continue to be impressed by and proud of the accomplishments of so many M.I.T. graduates whom I encounter frequently. Right on!" Nate has received the First Decennial Award from the Federation of Materials Societies.

William W. Saunders of Naples, Fla. writes, "September 1983 is our 50th wedding anniversary. We gave each other a new house on the Loch Eden shores of Lake Winnespausake, Meredith, N.H. We spend five months in New Hampshire and the rest in Florida. We are both in excellent health. Regards to all." . . . I have received a sad note from Marie, wife of Major General **Leslie Earl Simon** of Winter Park, Fla.: "General Simon is in a nursing home, having had a stroke about three years ago, which left him with no memory and unable to walk and talk. Thank you for your birthday card to him. It helped me." . . . **John H. Tomfohrde** of Somerville, Mass., another member of S.H.S. who entered M.I.T. as a freshman, writes, "I still work 40 hours as a draftsman at Ames Safety Envelope Co. of Somerville, Mass. I enjoy my work and I like to keep regular hours. Getting a pay check every week makes me feel that I am still a useful member of society."

On September 22, 1983, our 55th reunion local committee had a dinner meeting at the Faculty Club at M.I.T., led by **Jerry Gardner** our general chairman. Those present were: Sally and **Bill Bowie** (president), Helen and **Karnig S. Dinjian**, Fran and **Paul Donahue,** Ruth (Mrs. **Jim**) **Fahey**, **Jerry Gardner**, Ellie (Mrs. **Sol Horwitz**) **Seghera**, Dorothy and **Herman (Fritz) P. Meissner**, Ruth and **Joseph L. Speyer**, and Ethel and **David H. Wilson.** Also present were Joe Martori, M.I.T. class and course coordinator, and his secretary, Nancy French. Jerry reported the details of the first mailing notice of the reunion. There were 86 responses, 33 "yes" with spouses totaling 61, 30 "possible" and 20 "not coming." There were 76 members who sent their $25 dues, the majority of whom are unable to attend. **John F. Dreyer** of Cincinnati, Ohio generously sent $50 for his dues. There were also indications that six members of our Widows Program may also attend, two of whom were present at the meeting. For those of you who have not made up your minds, Jerry is planning to send a second letter of solicitation sometime in January or February.

I regret to announce the death of the following members of our class: **John Saloma** of San Francisco, Calif. on July 6, 1983; **H. Dayton Wilde** of Houston, Tex. on July 20, 1983; and **J. Gordon Carr** of New York, N.Y. on August 10, 1983. John Saloma had a distinguished career in the political science field. He helped found Ripon Society, a moderate Republican research and policy organization. He was well known for pioneering studies in congressional reform and political party organization. He held a masters as well as a doctorate from Harvard in political economy and government. He was a Fulbright Scholar at the London School of Economics and a staff associate of the John F. Kennedy Institute of Politics at Harvard. In 1969 he was selected as one of "Ten Outstanding Young Men" by the U.S. Junior Chamber of Commerce. He taught political science in a number of colleges—M.I.T., the University of Massachusetts, San Francisco State University, and St. Mary's College in Moraga, Calif. Dr. Wilde headed research and development at Humble Oil and Refining Co. (Exxon) until his retirement in 1965. He also served as secretary of the Exxon Educational Foundation. He held a bachelor's and a master's from the University of Texas and his doctorate from M.I.T. He also attended Harvard Graduate School of Business. He received the Ramsborn Award presented to the outstanding graduate of the University of Texas. He was a fellow of the American Institute of Chemical Engineering, a trustee of the Society of Professional Engineers Foundation and Legion of Honor of American Institute of Mining. He is survived by his wife of 53 years, the former Louise Key, and three sons. . . . Gordon Carr was a successful practicing architect in New York City and a good artist specializing in water colors. He has had many exhibitions and won many prizes. He had a stroke some five years ago which left him paralysed and bed ridden.—**Karnig S. Dinjian**, Secretary, P.O. Box 83, Arlington, MA 02174

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Marge and **Hal Spaans** celebrated their 50th wedding anniversary last June at a party given by the Spaanses' children, Dave and Judy, and their spouses, and attended by "friends and relatives from Maine to Florida." After the party the Spaanses took a two-week trip to Alaska, the most noteworthy incident of which occurred in Glacier Bay when one of the glaciers "calved" and produced a wave that rocked the Rotterdam, on which they were passengers. Hal still conducts two-week seminars for United Telephone System several times a year and says that "teaching individuals who want to learn is a great satisfaction." . . . **Mo Shaffer** and his wife made a leisurely trip around the world last spring and summer. In addition to visiting the usual tourist spots, they joined "a people-to-people delegation of infectious disease types" on an extensive tour of mainland China, attended Margaret's 50th reunion at the Gymnase de Lausanne in Switzerland, an international Rhodes Scholar reunion in England and a reunion in Burlington, Vt., of former workers at the Albert Schweitzer Hospital in Haiti where Margaret worked for a time. . . . **Hank Luykx** retired in the mid-'60s as chief of the Biometrics Division of the Surgeon General's Office and spent most of the next 12 years sailing his sloop around Chesapeake Bay with occasional cruises to Maine, Rhode Island, Florida, Venezuela and Grenada. Some years ago he ran into **Ernie Reisner**, who was also sailing on Chesapeake Bay. Since 1979, Hank has had to give up sailing and has moved to Frederick, Md. He and Barbara celebrated their 50th anniversary in Hilton Head, S.C., last July.

Tom MacLaren retired a number of years ago as general sales manager of Browne and Sharpe Manufacturing Co., makers of machine tools and precision measuring equipment. The MacLarens live in North Kingstown, R.I., where Tom is active in church work and on the board of St. Mary's Home for children. . . . On a personal note, I am at last able to report the birth of my first grandchild, a granddaughter, Kira, on August 4. In addition to

Kira Lister, '04

your secretary, Kira has five other M.I.T. relatives: her father, Robert Lister, '73; her mother, Nina Rosoff Lister, former assistant professor at the Sloan School; uncle Eric Rosoff, '67; uncle Peter Rosoff, '61; and granduncle Donald Lister, '34. We anticipate that Kira will enter M.I.T. with the class of 2004. . . . Unfortunately, we have a couple of downbeat items to report this month. A sad note from Kathleen McKenna brings the news that **Frank McKenna** has had a series of strokes and is in a nursing home in Spring Lake, N.J. Brain damage has paralyzed his right side and largely destroyed his ability to communicate. . . . We also have a note from Katherine Lyle telling of **Charlie Lyle**'s death from cancer on December 13, 1982. Charlie worked as a mechanical engineer at the Aberdeen Proving Grounds in Havre de Grace, Md., until his retirement in the mid-'70s. He was one of the developers of the first tracking telescope used by NASA. He lived in a 200-year old fieldstone farmhouse "on the picturesque shores of the Susquehanna." He was an active farmer and, as of 1979, maintained a herd of beef cattle. He was also active in conservative politics. In addition to Katherine, he is survived by a daughter Ellen and grandson Lyle Bradley.—**Gordon K. Lister**, Secretary, 294-B Heritage Village, Southbury, CT 06488

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A few weeks ago, I wrote a letter to our classmate **John Minami** in Tokyo and asked him to bring me up to date on his activities since leaving M.I.T. I was very pleasantly surprised to receive the book, "Selected Papers of Dr. J. Kazuo Minami," in the mail a few days ago. John also sent me a note which, among other things, referred to a section of the book which contains a most interesting history of John's activities at M.I.T. and his business life. Following is an excerpt: "My parents went to America in the early years of this century in the employ of Tokyo Trading Co., which was engaged in railway construction in the northwestern region of the country. I was born in Seattle on June 30, 1907, and my birth was registered at the City Hall and also with the Japanese Consulate in Seattle. My mother returned to Japan with me soon after my birth, and I spent my childhood in Nara until the summer of 1918, when my parents decided to take up residence in the States. I was in the fifth grade of grammer school and 11 years old. I still remember clearly the grand scale of the rugged mountains in the background of Seattle. Father bought a house, and we were the first Japanese family to move into the white neighborhood. Anti-Japanese feeling was

strong, and my lack of knowledge of English caused constant friction and irritation with boys of my age in the neighborhood. However, after several decisive fights and passage of time, we were able to get along somehow. By the time of my graduation from high school in 1926, I was able to understand the structure of the English language through my study of Latin. It was my father's wish that I study architectural engineering at the Massachusetts Institute of Technology after the 1923 Kanto earthquake. Due to strict entrance requirements at M.I.T., I attended Chauncy Hall School in Boston. I was admitted in 1927 and enrolled in the Course of Building Construction. The atmosphere in the Boston area was more friendly than on the Pacific coast. I completed the requirements for the master's degree in the summer of 1932, but there was no employment. I returned to Japan. Dr. Naito offered me work in his Wakamatsucho office, where I was to spend the next four years, learning the rudiments of earthquake-resistant design. Dr. Naito also arranged for me to teach at Koto Kogakko, which was an evening extension school of Waseda University, to supplement my income. In the fourth year, contrary to my expectations, I received a stern letter from my father ordering me to quit Dr. Naito's office and return to America to work or resume study at Waseda University on an allowance of 100 yen per month from home. I finally decided not to return to America but to stay in Japan to stake out my future here. So I again became a graduate student, in the Department of Architecture, Waseda University, during 1937 to 1939, and concentrated on the study of soil mechanics and foundation engineering. In the meantime, I had married in 1936, and my father provided us with a new house in Denenchofu which we sold in 1937 and moved into a small two-room apartment. In the spring of 1939, the College of Engineering was established at Waseda University and I was offered a teaching position. Thus began my affiliation with Waseda University which continued until my retirement this spring. Just prior to this I had accompanied Dr. Naito, who was invited to lecture on earthquake-resistant design of buildings at the University of Santo Thomas in Manila, Philippine Islands. Early in 1940, a cable was received informing me of the critical illness of my father, who had visited Japan in 1939 and had returned to Seattle in the fall. I made preparation to visit my father and was en route to Seattle when a cable was received in the mid-Pacific informing me that father had passed away. He died, however, knowing that I had been promoted to assistant professor at Waseda and my wife was expecting a child in April. On this occasion, I was forced by circumstances beyond my control to make another important decision. When I applied for a U.S. passport, I was told that Japan was designated to be in the danger area due to strained relations between Japan and U.S.A., and I was advised to go to Seattle and not return to Japan. I was also advised that my pregnant wife would not be permitted to go to Seattle as she is a Japanese national. The young vice-consul at the American Embassy told me that this was the law of the land passed by Congress and that I could go, as a native-born American, but my wife would not be permitted entry to America. I felt obliged to return to Japan and be with my wife, who was expecting a child in April, whereupon I made the decision to give up my U.S. citizenship and obtained a U.S. visa on a Japanese passport issued me by the Foreign Ministry. My first 26 years, from 1907 to 1932, were devoted to growing up and getting an education; the six years from 1933 to 1939 gaining practical experience and further study on soil mechanics and foundation engineering; and from 1939 until my retirement from Waseda University in March of this year as a teacher and engineer." I wish that we could print John's entire autobiographical section, but I'm afraid space wouldn't permit. If any classmates would care to read the entire fascinating section, please let me know and I will send along a photostat of it.

A recent letter from **Dick Blasdale** sadly tells of **Eliot "Ducky" Graham**'s death and brings us up to date on Dick's post-retirement activities: "Ducky" Graham and his wife 'Jo' (Josephine Jacoby) were killed in an automobile accident on August 1, 1983, in California. I received a letter from Jo's sister-in-law giving me the details of the tragedy. They were coming out of a Leisure World park when a driver entering the park lost control of his car, crashed over the separating barrier, and landed on top of their car. Ducky apparently was killed instantly from a cardiac arrest, and Jo died a few hours later in a hospital. The only relief from the tragedy is that they were together at the end, and one was not left to suffer the loss and loneliness. They seemed very happy and had settled down to enjoy their golden years together. As you probably remember, Ducky and I had been corresponding over the last few years, and I was able to get his address in California from the 50th reunion book. I suppose we have to expect things like this in our later years but I am sure you will agree that it doesn't lessen the shock. . . . I have had to limit my activities quite a bit because my damn legs are wearing out, but no other major problems, for which I am grateful. I keep my house up to snuff (not hard when you are the only one in it), get two swims in at the 'Y' twice a week (the only exercise that is comfortable to me), and enjoy transporting my grandchildren around to their various activities when Mom and Pop are busy. Spencer is is his third year at Tabor Academy—a good student and on the hockey team and crew. Amy is a doll, full of life and getting to be quite an equestrian." Thanks, Dick; although the letter contained sad news, we appreciate hearing from you.—**Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; **Ben W. Steverman**, Assistant Secretary, 3 Pawtucket Rd., Plymouth, MA 02360; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, MA 02158

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Phylis and **Don Brookfield** have just returned from a three-week jaunt in Ontario and Quebec. They visited friends and relatives and took in a windjammer cruise for a few days. When I told him that I have finally joined the Grandfather Club, he said "I don't want to play one-upmanship with you but this summer I had two more grandsons, which now makes a total of five grandaughters and four grandsons." . . . Ruth and and I are leaving very soon on a four-week trip to the Orient. Perhaps I'll have a report to make in the next issue. . . . **John Brown** has been doing a lot of traveling. In June he was in Rome and Athens. Recently we spent two weeks in Spain. He lost **Juan Serrallach's** address and was disappointed that he could not meet him. **Al O'Neil** is working part-time in Project Accounting for the Technology Adaptation Program. When he was at the Cape this summer, he spent some time with **Carl Bunker** who is now retired from Allied Chemical Corp. . . . **Al O'Neill, John Brown, Don Brookfield,** and **William Pearce** assisted the Alumni Fund at the Association's October Telethon. . . . His wife Kay tells me that **Bob Minot** is a very busy semi-retired architect. They spend much of their time in Nantucket. Bob has designed many of the homes there and has just finished one. His next design is for the owner of a 100-foot sloop, *White Hawk* ($2 million). His wife wants a house designed by Bob Minot. Kay and Bob enjoy very much their life and involvement with their clients.—**Melvin Castleman,** Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

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Since our reunion at Cambridge and on the Cape, our members have been traveling around and making plans for even more getting about. **H.O. Somers**, who lives in Tenants Harbor, writes that Ruth and **Joel Stevens** came to see them. Ellie and **May Mayer** and Marge and **Bob Lodbell** were there at the same time, and the **Robert Heggie**s came too. Later Ruth and H.O. returned the visit to the Mayers in Washington.

Jane and **Dick Malloy** live on the coast of Maine, only a mile or so from the Somers who are involved in weaving, wine-making, gardening, sailing, traveling, bridge, and a new hobby—mushrooming. . . . **Warren Henderson**, our secretary emeritus, writes to ask if he is the only great-grandfather in our class. What do some of you old men have to say? By the way, it is about time for Warren to join the ducks and geese and make that annual trek to Florida.

The **Niazi Mostafa**s stayed in the States a while after the reunion and saw the **Dick Morse**s a number of times. Would some of you Course VI men like to write Niazi? Ask Dick or me for his address in Cairo.

We are all signed up for our 55th reunion at Chatham Bars; our ever-on-the-job president, **Dick Morse** took care of the reservations. And as a closing report, we hear that our last reunion was a financial success; we did a bit better than break even under **George Stoll**'s direction. . . . **Chuck Fulkerson** reports that their family wanted to go to Italy for Christmas, but as early as August the required 12 reservations were not available on three tours. . . . **Jack Andrews** says to thank all concerned with the reunion for a good job well done. We all agree. After the Cape he and his Mrs. went to Montreal for daughter Gwen's wedding.

In our moving here and there, my *Technique* has disappeared. During our senior year, I think we had an especially good basketball team. Won't someone who has a *Technique* and remembers basketball players look up some names and ask for their addresses. Then you can write some reminiscences and some current news on "our boys" we can use in these columns.

Speaking of 1932-33, there is a letter from Leonard V. Gallagher, student financial aid director, who looked up the figures for our senior year and wrote that tuition that year was raised to $400—don't you remember—with awards made on the basis of $1,200 for all expenses. While we were in Cambridge in June, *The Tech* carried a story about tuition for the current year. The figure is $14,800!!!

With these notes all the news on hand has been covered. Let's hear from you about yourself (and others, as Somers did) or drop me a note just about other members of the class if you are too modest to write about yourself. . . . but really, there are some interested in your news. I'm still here, let me hear.—**Beaumert Whitton**, Secretary, Sharon Towers, Cottage 112, 5150 Sharon Rd., Charlotte, NC 28210

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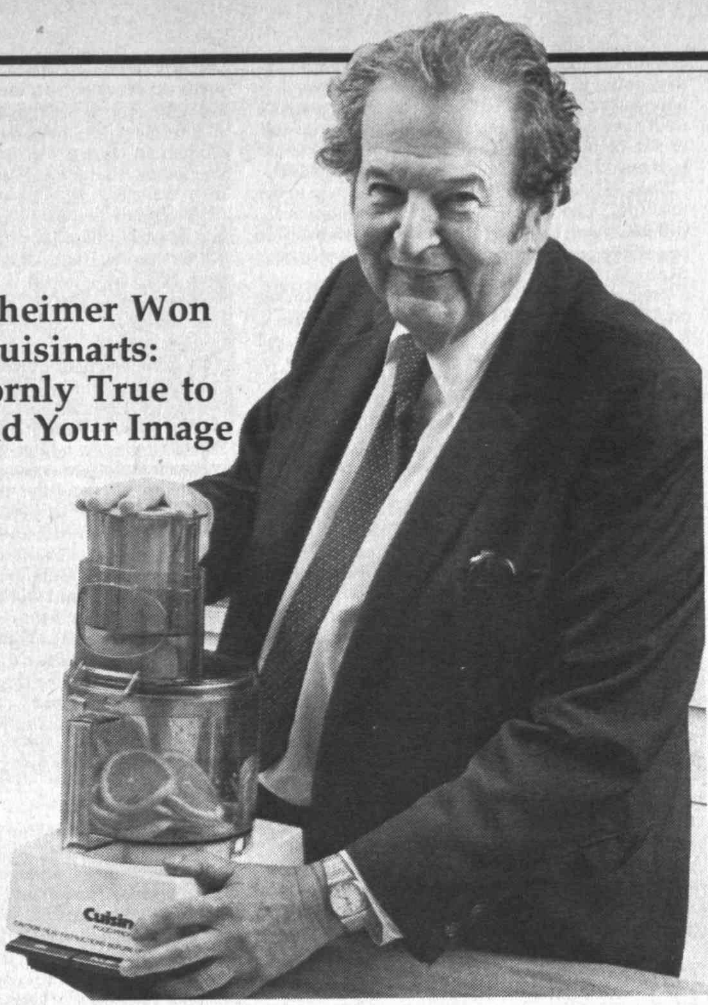
Rhoda and **Bernie Nelson** had a mini-reunion in South Harwich back on August 18, attended by the following '35ers and their wives: **Herb Anderton**, **Leo Dee**, **Hank King**, **Bob Lindenmeyer** and **Prescott Smith**. Refreshments and supper, along with lots of talk, were enjoyed by all. Dorothy and **Fran Muldowney** had to cancel at the last minute. **Anne Goodale** and **Kathryn Ryan** (widows of Charlie and John) had hoped to be able to attend.

The 50th Reunion Committee had a working meeting on September 13 and made the following decisions: Class dues of $30 will include a copy of the class directory. Red jackets complete with the M.I.T. seal will be available for about $75 to $80. You will receive a letter before May 1, 1984, with forms to complete for the directory and an order blank for the red jacket. The general plan for the reunion starts with your arrival at Cambridge on a Thursday in June 1985, with registration at McCormick. Cocktails follow at the President's House Reception, then the Buffet Class Dinner (class only) at Walker Memorial with President Gray. Buses will take us to Pops at 7 p.m. There will be a post-Pops party, with a singing group from M.I.T. to entertain us. On Friday we shall have a continental breakfast at the Student Center, and sometime that morning oarsman from our 1935 crews will boat an eight-oared shell for a very brief row on the Charles. After the Alumni Lunch at which we present our 50th Reunion Gift, we shall leave for the Wianno Club on the Cape. Cocktails



How Sontheimer Won With Cuisinarts: Be Stubbornly True to Yourself and Your Image

American difficulties competing with Japan have aroused fresh interest in what makes for successfully innovative companies. An M.I.T. class in entrepreneurship recently heard an unusual answer: be stubborn.

Speaking of his first large-corporation job after graduating into a bleak employment climate for physicists, **Carl G. Sontheimer, '37**, said, "I was always at odds with management. I couldn't get them to try anything I wanted." And so, in succession, he founded two electronics companies and, after "retiring," his present company—Cuisinarts, Inc., whose goal is to make things easier in the kitchen for ambitious cooks.

"All companies pass at least one fatal crisis," Sontheimer said, "and they only get through them because the manager was too stubborn or too stupid to know he was licked." He added, "The surest way to fail is to quit."

Before starting Cuisinarts, Sontheimer considered starting a company for making or marketing home-security devices. "I spent months researching the field," he told the class conducted by Professor David G. Jansson, '68, director of the Innovation Center, "but I couldn't get committed to it. If you're not absolutely and thoroughly dedicated to the goal you want to achieve, stay out."

Then Sontheimer's attention was turned to the idea of a company concerned with good cooking. Having spent much of his youth in France, he was bilingual in French and English. He had a good theoretical knowledge of cooking; he had an engineer's outlook on the evaluation of a product's performance.

Although the proposed company was to be "part time," Sontheimer took the concept seriously enough to spend some weeks choosing a name and some weeks more choosing a mission—or the "image" of what he wanted the company to be known for. But, like too many entrepreneurs, he worried too little about the market. "Every time you think of something useful you are in some danger of doing it before knowing if the return will justify the effort," Sontheimer said.

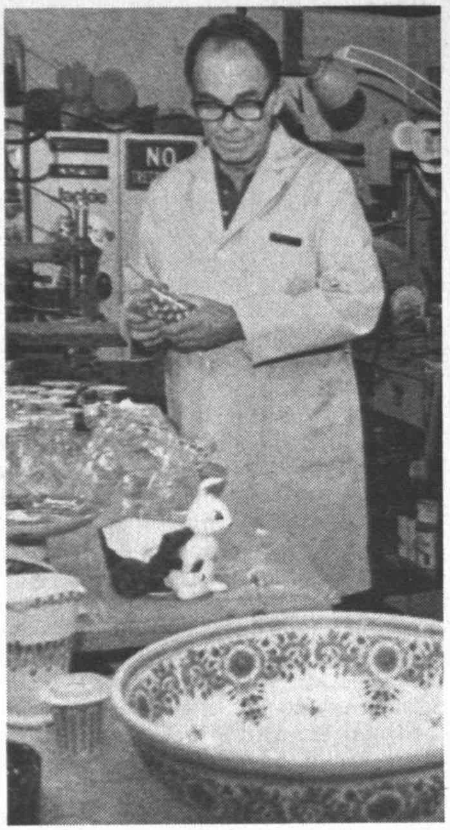
The company started as an importer of advanced stainless steel cookware. At the first show where the cookware line was introduced, Sontheimer met the Frenchman Pierre Verdun, who, he told the class, had mortgaged his parents' vineyard to develop and build a food processing machine he was selling successfully to the restaurant trade. The machine could chop meat, puree vegetables, slice, shred, and cut vegetables into french-fry shape—all practically without accessories. "In about two minutes I became his American distributor," Sontheimer recalled. The new machine was "a mutation, different from any earlier kitchen appliance." Because of this, Sontheimer told the class, he gave the machine a new name: the food processor.

To sell this unfamiliar device, Sontheimer had to use some innovative techniques, including loans of the machines to such leading cooking experts as Craig Claiborne and James Beard, who both praised it, and placement of the machines in the rapidly expanding network of cooking speciality stores.

As sales volume built, competition began proliferating. Thus pressure built up for ever-higher quality in production. In this battle for quality control, Sontheimer said, "You can win it, but you can never consider it won. You have to fight it over every day." Of the competition that was multiplying by leaps and bounds, he said, "you can die very quickly." That's where image begins to count. The image of a cooking-equipment company should be strong enough, Sontheimer said, that a cooking enthusiast would ask about a new product: "Does Cuisinarts sell it?"

The competitors chose to introduce "15 machines as good as ours at lower cost." But, said Sontheimer, "We went the other way: better machines costing slightly more money. We remain the top machine for food editors and consumer magazines." Without such innovation, Sontheimer said, "you don't keep the image you've tried so hard to create."

To questions from Howard W. Johnson, chairman of the Corporation and President-Emeritus Jerome B. Wiesner, Dr. Sontheimer said that American schools could teach scientists and engineers the grave importance of marketing and other skills vital to success in entrepreneurship. "Success is the product of the several qualities, not the sum," he said. "It depends on the determination of the entrepreneur."—*Victor K. McElheny*



Walter C. Kahn, '40, applies engineering principles to mend anything from china to small wooden or jade sculptures to a 1917 Nymphenburg porcelain parrot. A retired metallurgical engineer, he is known as the Westport, Conn. Mr. Fix-it.

Most restorers, he says, have artistic backgrounds, but being an engineer allows him the advantage of using state of the art materials to glue precious heirlooms back together again.

Kahn claims his most difficult job was an intricately painted Ukranian egg shell. A man whose daughter had given her father the egg as an Easter present when she was a little girl brought it to Kahn in pieces. It took the master craftsman about four hours to piece the shell back together and repaint the exterior with watercolors similar to the originals. *(Photo: Theodor Litsios)*

and dinner that evening. After breakfast on Saturday, golf and shopping are available, and we'll have a clambake at about 7:30 p.m. On Sunday we shall have our continental breakfast and more golf, or you can relax and show up for brunch. Then off to home. Total estimated cost per couple is $600.

The 23rd Annual '35 Golf Tourney is down to the final four. **Chet Bond** (last year's champion) and **Bill Bates** won their flights and **Dick Shaw** has won one of the consolation flights, with the other between **Sam Brown** and **Frank Hatch**.

I regret to announce the death of **Cason Rucker** on June 20, 1983, at St. Simons Island, Ga. He leaves his wife, Kathryn, two sons, a daughter and six grandchildren. Our deepest sympathy goes to all of them.—**Allan Q. Mowatt**, Secretary, 39 Congress St., Apt. 5, Nashua, NH 03062

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This month the news is both sad and happy. **Harrison Woodman**, retired marine engineer and shipping company executive, died last June 28. Since 1937 he had been active in marine transport, most recently with Refineria Panama, S.A., which merged with Texaco prior to his retirement. He was a life member of the Maritime Museum of Bath, Maine and had recently designed and built a unique display of steam vessels entitled, "The Century of Maine Steamers," for the museum. Woody made his home in Rumson, N.J., where he was active in church and community. He is survived by his wife of 42 years, Elizabeth, a son, two daughters, and seven grandchildren.

The happy news was a post card from **Henry Runkel** announcing that he and Natalie were winding up last summer with an Alaskan cruise and suggesting it might be "fantastic for our 50th reunion!" He promised to write more sometime. How about the rest of you?—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, CT 06091

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Eugene P. Cooper, La Jolla, Calif., is still working as director for science and technology at Naval Ocean Systems Center, San Diego, Calif. Gene was scientific director of the Naval Radiological Defense Lab in San Francisco and continued during the last nine years of its existence (1960-1969). He writes that his hobbies are music (piano playing and a classical record collection), astronomy (small telescope sky watching), swimming in his own pool, and helping his children and grandchildren with science and music. His wife Marjorie's interests are mathematics and computer science.

Fred Altman, Falls Church, Va., retired last April but is now working full time at Cybercom as a radio scientist, studying radio transmission through forests. He is still hiking and square dancing. His son Charles is a professor at the University of Iowa; his daughter Jane is a nurse in Alexandria, Va.; and daughter Ann is a programmer. . . . **Frank D. Lewis**, Lexington, Mass., retired from General Radio in 1969 and then from James Millen Co. in 1977. He is currently working part-time as chief engineer for Caywood Electronics, Malden, Mass. He received the President's Certificate of Merit in 1946, and the Minuteman Council, Boy Scouts of America, Silver Beaver Award in 1973. Frank reports he went to the 50th reunion of Class of 1933 at Central Methodist College, Fayette, Mo. in April. His wife Bea works in a doctor's office and sings in the church choir. They have three children (Patricia, Robert, and Peter) and one grandchild (Rebecca Joy). Peter (M.I.T. '75) is still a Ph.D. candidate in biology at Yale University.

Robert E. Hopkins, Rochester, N.Y., professor emeritus of the University of Rochester Institute of Optics, has been selected to receive the 1983 Gold Medal of the Society of Photo-Optical Instrumentation engineers. The Society cited Professor Hopkins for his leadership, observing that he is "known and respected throughout the world for his ability to combine multiple scientific disciplines to produce practical results." He was also recognized for his many achievements in the field, including the design, development, engineering, and manufacture of important optical instruments.

I regret to report the death of **Goodwin R. Gay** on August 31, 1983 in Worcester, Mass. He leaves his wife Joan of 90 Maynard St., Northboro, MA 01532, and two sons (Robert, of Seattle, Wash., and Gardiner, of Somerville, Mass.).—**Lester M. Klashman**, Assistant Secretary, 289 Elm St., Medford, MA 02155; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

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Jean and **Ed Hadley** took a trip to Russia, Siberia and Mongolia last fall. Ed says that Moscow is like Washington—the farther you get from it, the less paranoid and more reasonable and likable the people become, and the more likely they are to cooperate in a lasting peace. Ed also wants to remind you that all Alumni Fund contributions for the next five years count toward our 50th reunion gift. Everything counts, but gifts designated for the Class of '38 Fund will build up our own scholarship/student loan fund.

We just learned that **Francis Stein** died last June in Annapolis, Md. Prior to his retirement in 1974, he had worked for the Department of Labor in Washington.—**Armand L. Bruneau, Jr.**, Secretary, 663 Riverview, Chatham, MA 02633

39 45th Reunion

Holden "Bob" Withington retired as vice-president of engineering after 42 years with Boeing and a career full of major achievements in the dynamic airplane industry. Bob and Betsy expect to share their time with family, a 42-foot cutter-rigged boat moored alongside their Lake Washington home, skiing and administering the Crystal Lake Mountain Resort, and playing tennis. Bob received his pilot's license five years ago, shares ownership of a retractable-gear 182 Cessna, and is qualifying for more advanced pilots' licenses. . . . **Jim Barton** also retired after a full career with Boeing. Jim's most recent responsibilities were in the administration of Boeing's International Organizations. After a round-the-U.S.A. junket, Jim will return to the northwest to resume duty as oft-reelected Mayor of Hunts Point. Jim and Mary expect to be at the reunion, and they report other Seattle '39ers there will include Betsy and **Bob Withington**, Austie and **Hans Bebie**, Nancy and **John Alexander**.

As a memorial to his beloved wife, **Gordon Pope** underwrote the rebuilding of the historic Whittier Covered Bridge that spans Bear River near West Ossipee, N.H. Governor Sununu spoke at the presentation ceremony, and the August 20 *Boston Globe* published a multi-column story and pictures. **Fred Schaller**, **Manning Morrill**, and **Fred Grant** all clipped the newspaper and sent the news.

Fred Grant continues his financial managing at Wellesley Hills and writes, "Ginny and I have no plans for moving but recently caught ourselves several times wondering what on earth we will do about clearing out the attic." . . . **George Morrison** retired from the building construction business to reside near Peterborough, N.H. George and Marge called after their recent tour of Yosemite to say they expect to be at the reunion.—**Hal Seykota**, Secretary, 1603 Calle de Primra, La Jolla, CA 92037

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Our class president, **Bruce Duffett**, writes that he attended the National Alumni Conference at Tech in September, where he met **Sam Goldbleth**, **Russ Haden** and **Jim Baird**. **Louis Russoniello** and **Loren Wood** were also listed on the register of attendees, but he did not have the pleasure of greeting them. At the Awards Luncheon, a Morgan pewter plate was awarded to **Marshall McCuen** for outstanding service to the M.I.T. Educational Council, but un-

The 1983 Bronze Beaver to Ernest U. Buckman, '46 (right), from Robert W. Mann, '50, president of the Alumni Association. "Ernie's reputation as an effective leader and key resource has earned him great respect from those whom he has assisted: M.I.T., the Alumni Association, and our Pittsburgh area alumni. Pittsburgh area Alumni Fund telethons and related activities have grown stronger and more successful under Ernie's chairmanship." He is "an exemplary alumnus whose loyalty, devotion, and deep appreciation for the Institute have earned him this honor." ***(Photo: Scott Globus, '84)***

fortunately, he was unable to be there in person to receive it. Paul Gray's announcement of Project Athena—a cooperative program with D.E.C., I.B.M. and M.I.T. to develop new techniques for computer uses in education—was exciting and full of promise.

A news release announces that the Board of Trustees of Boston University has established a new Center for Technology and Policy with **J. Herbert Holloman** as its director. This new center will study effects of technology on the social, political, economic and industrial systems of the United States and other nations, and will also train future leaders for both industry and government. Herb, who established the Center for Policy Alternatives at M.I.T. in 1972 and served as its director until this past year, says that "new techniques of industrial management are needed to assure the commercialization of new technology." At present, Herb is a member of the board of directors of Bell and Howell Co. and a member of the American Academy of Arts and Sciences and the American Physical Society. He is also a foreign member of the Royal Swedish Academy of Engineering Sciences.

Amos E. Joel, fellow of the I.E.E.E. and a pioneer in the development of electronic switching systems, was selected to receive the Centenary Award of the International Telecommunications Union, a U.N. agency with 157 member nations. Amos, a holder of more than 70 patents, recently retired from Bell Laboratories, Holmdel, N.J., where he had worked as a switching consultant for more than 40 years. He is now executive consultant for A.T.&T. International. In the 1960s he helped develop Bell's first electronic switching system, which was quickly adapted for national and international use. Amos has written numerous articles and books on his field, most recently, "Switching Technology (1925-1975): A History of Engineering and Science in the Bell System."

A note from Springfield, Mo., indicates that **Gary Wright** would like to challenge the record for most grandchildren. He has eight grandsons and one adopted granddaughter, spread from Madison, Wis., to Corvallis, Ore., to Anchorage, Alaska. All future M.I.T. alumni?

Class treasurer **Edgar Bernard** reports that invoices for yearly dues were mailed in the fall and that the checks have been flowing in from far and near. If you haven't sent your check yet, his address is 57 Winn St., Belmont, MA 02178. . . . Just one more year to our big 45th. Your committees are hard at work on projects to make this a super reunion.—**Donald R. Erb**, Secretary, 10 Sherbrooke Dr., Dover, MA 02030, (617) 785-0540

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Luke S. Hayden writes: "In December 1982, I took early retirement as chairman of the board of the City Savings Bank of Pittsfield with which I had been associated as president from 1959 until 1981. In January 1983 I became a consultant for Crawford and Sammut, Ltd., an institutional investment management firm in Syracuse, N.Y. It is my responsibility to introduce the Crawford and Sammut plan to Thrift organizations in Massachusetts, New Hampshire, Vermont, Maine, Alabama, Georgia, and Florida.

"Dorothy and I purchased a condominium in the Glades Country Club, Naples, Fla. in January 1983. We plan to spend seven months there and will be in Pittsfield during the summer and the fall."

Dick Feingold, '43, sent us a *Los Angeles Times* clipping (October 2, 1983) featuring **David Jacobson, Jr.**, architect. David has designed or remodeled a dozen Casinos. He has offices in Arcadia, Reno and Atlantic City. Among his present projects are Huntington Park Poker Club, a church school in Tujunga, a Reno helicopter facility and a 1,200-unit Atlantic City condominium complex, which he believes is one of the largest multi-unit residential projects in a single building in the U.S. He and his wife Katy, who is his business manager, maintain a home in Pasadena. His hobbies are swimming, tennis, golf, and waterskiing. David is a workaholic who insists he'll never retire.

Zack Abusa writes: "Maizie and I are still enjoying retirement at our apartment on Longboat Key, Fla., with summers at Chautauqua Institute, Chautauqua Lake, New York. We are sailors and tennis buffs, and enjoy visits from our kids from time to time. Daughter Hayat is an M.D. specializing in family practice, and Robert and Richard are together in real estate in Northhampton, Mass. They rehabilitate older buildings into residences and into commercial space. . . . And oh yes, I have taken up windsurfing in my dotage."

Looking forward to seeing you at our 45th, Zack.—**Sepp Dietzgen**, Secretary, Box 790, Cotuit, MA 02635

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Got a little mail, so I will not have to "fabricate" an entire column. **Art Power** has moved to Boulder, Colo. and writes that he is "fascinated" by the rugged Great American Desert area. Art is with the Solar Fuels and Chemicals Research Division of Solar Energy Research Institute. He says that he is working on saving all of the U.S. in the next century by means of solar energy, specifically engineering alcohol fuels and chemicals.

From **Charlie Bossi**, a fast note since he was on his way to join a sight-seeing trip to Israel and Egypt. Charlie attended the Alumni Conference and received the Morgan Award for outstanding service to the Educational Council. Thelma and Charlie are building a new home on the No. 1 fairway of the Fazio golf course in Palmetto Dunes. They have no intention of moving from Dayton, but any of you golfers might give them a buzz if you are going by the South Carolina area.

Our class was represented at the National Alumni Conference (used to be called the Alumni Officers' Conference) by **Mort Goulder, Bob Howard, Alan Katzenstein, Lou Rosenblum, Lou Stouse, Jim Littwitz**. Jim is the chairman of the Alumni Fund Board and, from all accounts, is doing a great job.

One obit this month—**Lou Sutton**, who retired in 1976 as president of Plastech Corp., in Rock Hill, N.C., died in July. Lou's firm manufactured injection-molded plastics, and after retirement he built furniture and worked on his house. Lou was always handy with his hands and, as a youngster, crafted marionettes and soap carvings. A good background for the injection-molding business. We send condolences and sympathy to Jane and to the family.—**Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, NY 10605

43

There is a considerable variety of news this month, much of it supplied by **Jim Hoey**. Jim seems to spend a lot of time bumping into classmates and shaking them down for little news tidbits.

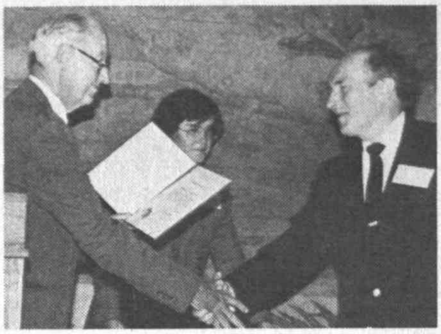
I am still hearing echoes from the great 40th reunion weekend. People have not stopped reminiscing about the early buffet at the Institute, the bus tour of Boston, the riotous bus ride down to the Cape with entertainment by **Angel del Valle** and **Fred Kaneb**, and all the fine things we enjoyed at the Cape Codder. Joyce (Mrs. **Edward Paul) Mikol** was elected an honorary member of the class. Joyce was involved in the contribution of some sub-gifts to the reunion fund. Friends may reach her at 3611 E. Curtis Park Dr., Sacramento, CA 95818. Jim Hoey and his reunion committee did a superb job and might be receptive to the idea of an encore for the 45th in 1988.

One fallout of the reunion is an effort by some wives (Leotas Hill, Marjorie Matthew, Susan Rorschach, and Jackie Ward) to organize a group for the quilting seminar at Casanovia, N.Y., in August 1984. Any other interested ladies should write to Mrs. **Stewart Hill**, 517 W. Hamilton Ave., Sherrill, NY 13461.

Other items from the Hoey Report: **Ralph Leader** has just retired as a major general in the Massachusetts National Guard. . . . **Bob Caldwell** is involved in a fabulous fishing contest at Boca Raton, Fla. One of the prizes will be an outing in Bob's obscenely large and luxurious deep-sea cruiser. Maybe it's not too late to send in your entry. . . . **Jim Hoey, Tom Maples, Jim McDonough,** and **Ken Warden** represented the class at the September National Alumni Conference in Cambridge. . . . From the deck of his 50-foot sloop **Bob Gunther** kept an eagle eye on the contestants in the latest America's Cup Race. He was aided and abetted by **Mort Spears, Ed Czar** and **Gene Eisenberg**. Hardship duty, indeed!

An obituary notice in the *Boston Globe* informs us that **Bob Bamford** died of cancer in Brockton Hospital last July 2. Bob worked for 37 years as a chemical engineer for the Bird Machine Co. of South Walpole, Mass. Our sympathies go out to Bob's wife, Frances, and to the rest of his family.

Jim has suggested that I include some good advice about the oil industry, so here are a few words of wisdom from J. Paul Getty. Getty's Rule: The meek shall inherit the earth, but not the mineral rights thereof. Getty's Formula for Fame and Fortune: Rise early, work hard, and strike oil.—**Bob**



The 1983 Bronze Beaver to Robert C. Cowen, '49 (right), from Robert W. Mann, '50, president of the Alumni Association. "Bob Cowen has given his wisdom and enthusiasm to many affairs of the Alumni Association and notably has been for 20 years a principal counselor, friend, and contributor (longest-running columnist) to *Technology Review*. As a member of the Alumni Council, the *Review*'s advisory board, the Alumni Association board of directors, and two Corporation visiting committees, he has earned the confidence and applause that come with the Bronze Beaver." (*Photo: Scott Globus, '84*)

Rorschach, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

44 40th Reunion

Many thanks to **James B. Weaver** who furnished a brochure for Venture Services promoting his consulting services available to chemical management. Our 25th reunion handbook describes his many activities up to that time. Since his retirement as vice-president for venture and capital appraisal for ICI Americas, Inc. in 1980, he has dropped his civic activities, is trying to form his own jazz band after playing his clarinet with several Wilmington, Del., bands over the years, plays tennis several times a week, and is writing more frequently than ever on a variety of subjects for an even broader spectrum of publications. Jim also noted that **Robert J. Reilly** retired in 1980 from ICI Americas as their financial vice-president.

Thanks also to **William A. Jack** who gives some of his valuable time, working in the Los Angeles area, to the personal solicitation program of the Alumni Fund.

Marguerite and **Ed Ahlberg**, Nancy and **Norm Beecher**, Jane and **Lou Demarkles**, Janice Kispert, **Pete Matthews**, Joe Martori (Associate Secretary of the Alumni Association), Ruth and **Norm Sebell**, and your secretary and guest motored to Cape Cod for a 40th Reunion Committee meeting at the home of the chairman, **Andy Corry**. By now you have received the first mailing outlining our schedule of events. Your prompt response to the reunion plans, the reunion handbook, and class dues has been greatly appreciated by your committee.

Recently another member of the Class of '45 told me that he read our class notes in the absence of his. Perhaps one of you '45ers with a fondness for writing and a guarantee of the publication of your handiwork will volunteer your services to write, at the most, eight sets of class notes per year.
—**Melissa Teixeira**, Secretary, 92 Webster Pk., West Newton, MA 02165

46

Another (yawn) day with the usual derth of imputs from classmates. I'm thinking of making up some juicy items, ala *The Enquirer*, about randomly selected alumni, hoping this might rouse folks from their torpor, at least to submit angry rebuttals if nothing else.

The only item I did get was a short, sweet note from **Dan Cooper** requesting a reprint of **Bill Cahill**'s crazy letter excerpted in the August/September issue of this *Review*. Turns out Dan (who got a "Dr." tacked on to his name somewhere along the way) runs his own video communications company from his place in South Orange, N.J. Thanks, Dan, for the note. Saved me from going bone dry. Since this will reach you after the New Year, hope y'all had a jolly holiday season and made resolutions—to WRITE—and so forth!!!—**Jim Ray,** 2520 S. Ivanhoe Pl., Denver, CO 80222

48

George Clifford was promoted by Corning Glass to market development manager for the Science Products Division which has sales in the $100-million range. He continues to have worldwide responsibilities in his new job. He had just completed directing the efforts to introduce pH meters with capabilities in ion selection in the U.S. Prior to the U.S. introduction he had directed the initial marketing overseas. He was also responsible for an R&D project to develop an instrument to characterize living cells. In a 3.5-hour procedure the instrument produces a "fingerprint" of the cells in a culture and can distinguish human from ape cells. This ability helps assure that research done at the cellular level is in fact being performed on the specific cell introduced at the beginning of the study and not on a cell that inadvertently has entered the system.

George joined Corning after they purchased his business, which manufactured densitometers that he developed. Over the years George has contributed much to our class. He was chairman of our 30th reunion, treasurer for five years, and last June he was elected president of our class. He and his wife Ginny live in Millis, Mass.

Bill Hosley was awarded the Harold E. Lobdell '17 Distinguished Service Award in September at the National Alumni Conference. This award recognizes his contributions as club president, Alumni Fund telethon chairman, personal solicitation vice-chairman and solicitor, and educational counselor. Bill has been a key figure to the ongoing success of the Rochester, N.Y. area M.I.T. alumni programs. His program innovations over the past several years have emerged as models for other alumni clubs (M.I.T. and non-M.I.T.) across the country.

Ezra Garforth is still working in men's formal wear. He now owns three Gingiss franchises. He is chairman of the local Red Cross branch and regional blood center. . . . **George Wood** resigned from Foster Miller, Inc. last December. He has started a company (out of his home in Lincoln, Mass.), engineering consulting in machine mechanism design and development for commercial clients. . . . **Dick Snow** is chief chemist at Eaton's Molded Products Division in Laurinburg, N.C.

Gene Purdum has recently been doing civil engineering design on ancillary projects associated with the new resource recovery project for Pinellas County, Fla. Preliminary test run shows a plant capacity to handle 2,200 tons of solid waste per day, with generation of 50 kilowatts of electricity, which will be sold to Florida Power Corp. . . . **Bob Gates** continues as vice-president, international, Northrup Corp. He has also been vice-president for the F-20 Tigershark program . . . . After a 25-year career with Arthur D. Little, **Art Fowle** has started his own consulting business offering services in mechanical and aerospace engineering. Art is pleased to report that things are going very well.

Buckley Collins sold his engineering and land surveying business and retired. He spends his time managing his real estate holdings, traveling a little, and doing some hunting and fishing. . . . **Walter Lowrie** became corporate vice-president and president of Orlando aerospace operations for Martin Marietta Corp. Before that Walter had been vice-president and general manager of their space and electronics systems division. . . . **Ed Frohling**, president of Mountain States Mineral Enterprises, was recently installed as the 1983 president of Associated Builders and Contractors. The nationwide association has 16,000 members. Ed founded his firm in 1969, and it has grown to be the 26th largest engineering/construction firm.

Al Kelly continues as president of A.D. Little's Program Systems Management Co. . . . **Jess Dew** is vice-president of engineering for R.L. Frailey, Inc. of Tulsa, Okla., a subsidiary of Tidewater, Inc. R.L. Frailey is an engineering and construction company in the natural gas processing field. . . . **Richard J. Conlan** has been named to head a new corporate electronic function of Metropolitan Life Insurance Co. in New York City. Richard is senior vice-president in charge of the electronic installations department at Metropolitan. He joined the firm in 1948 as a computer operator/programmer and project analyst for the company's Univac computer, the first in the insurance industry. Included in his achievements was the establishment and management of the company's main computer operation. Richard and his wife JoAnn are the parents of two sons.

In 1981 **Harold Abramson** died. . . . In 1982 **Andrew Raczynski** and **Milton Clark** died. On behalf of our class, our sympathies are extended to their families. . . . The mail bag is brimming over—thanks again.—**Marty Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49 35th Reunion

Jack Cook has retired from Bethlehem Steel after 34 years. He was manager of Transportation Services for the corporation. Jack will stay in Bethlehem and continue his other activities for the local Airport Authority and the Business Council of Pennsylvania.

We regret to report the death of Reverend **Boynton H. Tucker**, who passed away in March at his home in Malakoff, Tex.

I received two classmate phone calls in the past month. The first resulted in a visit from **Alan W. Collins**, whom I haven't heard from since graduation. Al is an assistant professor at the University of Southern California in the Institute of Safety and Systems Management. After retiring as a captain in the Navy, Al decided to go into teaching. He is travelling the 65 campuses of USC teaching systems management.

The second call was from **Andy Bigus** who was here in St. Louis to attend a reunion of the 97th Bomb Group, in which Andy had been a navigator in our Big One.

See you in a few short months in Bermuda. Please plan to come. We would love to see you.—**Paul E. Weamer**, Secretary, 331 Ridge Meadow Dr., Chesterfield, MO 63017

The 1983 Bronze Beaver to Russell N. Cox, '49 (right), from Robert W. Mann, '50, president of the Alumni Association. "His involvement in student affairs has been extensive and includes and eight-year membership on the Student Affairs Visiting Committee, six years on M.I.T.'s Advisory Council Alumni Steering Committee for Interfraternity Affairs, and the Institute Advisory Council for Independent Residence Development Fund. He has served on several Alumni Association national committees and was a principal founder of the M.I.T. Enterprise Forum, serving as its vice-chairman and chief fund raiser. (*Photo: Scott Globus, '84*)

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We regret to announce the death of **Jerome A. Lewis**. Jerry passed away on July 14. Our deepest sympathy to his family.

News notes to your secretary have been sparse. Something must be happening out there. Let's hear from you!—**John T. McKenna**, Secretary, 1 Emerson Pl., 11H, Boston, MA 02114

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We regret to report the death of **Arthur H. (Spider) Schein** of cancer on September 14. His architectural designs have become familiar in New England, especially at shopping malls where his firm was responsible for mall designs at Chestnut Hill, Natick, Cape Cod Mall at Hyannis, the Mall of New Hampshire, the Maine Mall, University Mall, the Fox Run Mall, and the Arsenal Marketplace in Watertown. He also designed various stores for Filene's, Jordan Marsh Co., and Sears Roebuck and Co. throughout the country and Puerto Rico. He is survived by his wife, Kelly, and daughter Jo.—**Gregor J. Gentleman, Jr.**, Secretary, Swanson Gentleman, Inc., 818 S.W. 9th St., Des Moines, IA

52

How carelessly we squander opportunity in our youth! For example, the last time I saw **Anthony Ralston**, about 25 years ago, I think, I missed the chance to ask him whether the numerical solution of a differential equation I am currently concerned with was meaningful, or merely an exercise in science fiction. Obviously, I could not then know I would care—the usual case—but, perhaps because of his modest demeanor, I did not even realize he would be the man to ask. His standard text, *A First Course in Numerical Analysis*, tells me enough that I know I may be in trouble. Perhaps his long-awaited, *A Second Course* . . . , will provide the answer I seek. Tony used to teach computer science at SUNY in Buffalo. According to the byline of a book review I noticed recently, he now holds a similar post at SUNY in Albany. By advanced extrapolation techniques, it can be shown that he will make it to the Big Apple by 2003. Obviously a simple linear extrapolation would merely take him to Boston.

Arthur William Carlson, who received an S.M. from M.I.T. after graduating from the University of Maine, died last June. An Air Force veteran, he worked at Air Force Cambridge Research Center and at Transistor Applications, Inc. as vice-president and director of research. He is survived by his wife, father, three sisters, and a brother.

Walter Tannenberg, a hematologist, died July 12, 1983. He graduated from Tufts Medical School after M.I.T. and service in the Air Force. He was on the staff of St. Elizabeth's Hospital and the New England Medical Center, Boston. In addition to his private practice, he was also on the clinical faculty of Tufts Medical School. He is survived by a brother and his mother.—**Richard F. Lacey**, Secretary, 2340 Cowper St., Palo Alto, CA 94301

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George Hegeman, who compiled all the results of our 30th reunion questionnaire, has mailed out copies to all of us who paid class dues. The results cover areas of education, business, money, family, etc., and provide some unusual insights into the lives of our classmates 30 years after graduation. Both George and **Dick Lindstrom**, our reunion co-chairman, work at Arthur D. Little in Cambridge, Mass.

George did a great job in putting the facts together. For example, 62 of the class' 100 respondents obtained a total of 76 advanced degrees of which 63 percent received at least one of them in the same field as their bachelor's degree. No wonder 78 percent of the class rated their M.I.T. background as relevant and another 20 percent said it was at least some help. Of course the sample isn't a completely random and scientific one, but it does make interesting reading.

We've received news from or about several of our classmates, but the amount of material is dwindling. Perhaps as you see our class notes appearing each month, you'll feel encouraged to send in some news. We just heard from **Brian Parker**, for example. He's one of several of us (about two percent according to the survey) who became a lawyer after graduation. He then went on to receive both a master's and doctorate in criminology from the University of California at Berkeley. Brian is now a professor in that field at California State in Sacramento, acts as a consultant for major universities and government agencies, and has numerous publications to his credit. Brian and his wife have two children and live in Fair Oaks, Calif.

Another classmate in academia, **Allan S. Hoffman**, who we last read about in the May 1983 class notes, was recently elected president of the Society for Biochemists, a group of 500 that is dedicated to basic research in the application of synthetic materials for use in diagnosis or therapy. Al is a professor of chemical engineering at the University of Washington and lives in Seattle. I last saw Al, his wife Susan, and their two teenage children when I lived in Seattle in 1979.

An article about **Herbert H. Richardson**, associate dean of the School of Engineering at M.I.T. informs us of his election in November 1982 as vice-president for research of the American Society of Mechanical Engineers. (Notice how up to date our information is—barely a year old.) In 1981, Herb was elected to the National Academy of Engineering.

Finally, an article was published a short while ago in the *Connecticut Businessman* about **Zane Yost**, who we recently saw in June at the reunion. Zane has his own architectural firm in Bridgeport where he recently completed a successful clustered housing project called Unity Heights which capitalizes on his philosophy that a sense of community will preserve and improve an area "more than all the police and money in the world."

Let's hear from more of you. I understand about half of our class gets *Technology Review*, and I'd like to write something about each of you over the next five years. That would be an average of about seven items per issue; we fell a little short this month.—**Wolf Haberman**, Secretary, 41 Crestwood Dr., Framingham, MA 01701; **Joseph M. Cahn**, Co-secretary, 289 Bronwood Ave., Los Angeles, CA

54 30th Reunion

John Peterson is now director of technology planning at B.F. Goodrich. John, who received a degree in law from the University of Akron in 1962, has been with B.F. Goodrich sinch 1965. During this period he has held several responsible positions including: director of corporate development, director of international development, and director of facilities purchasing.

Harvey Steinberg has established an endowment fund to support the Steinberg Prize, which is awarded annually to a civil engineering senior at M.I.T. Harvey is president of Beacon Contruction Co., Inc. of Boston. He and his wife Arline are the proud parents of Robert and Brenda. Robert, who is following in his dad's footsteps, graduated from M.I.T. with a B.S. in civil engineering and an M.S. in project management. Brenda, not to be outdone by her younger brother, has earned a B.S. from Wellesley, an M.S. from Harvard, and a degree in law from Boston College. She now specializes in corporate real estate law at the Boston firm of Sullivan and Worcester. Congratulations to Harvey and Arline, who indeed have much to be proud of.

We hope that 1983 was a good year for the members of the Class of '54 and their families. May 1984 be better yet!—**William Combs**, 120 West Newton St., Boston, MA 02118; **John Kiley**, 7 Kensington Rd., Woburn, MA 01801; **Louis Mahoney**, 52 Symor Dr., Convent Station, NJ 07961; **Dominick A. Sama**, 28 Chestnut Hill Rd., Groton, MA 01450

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Editor's note: The bad news is that the item about George B. Raymond Jr., M.S.T. '82, printed in this column in the October 1982 issue, was wrongly placed and should have appeared in the "Courses" section of the *Review*. The good news is that this error brought information about **George B. Raymond, Sr.**, who has been CEO of Raymond Industries (originally a family business) since 1967. He writes, "Raymond Industries has evolved into a holding company whose stock is traded on the American Stock Exchange, with major ownership interests in Raymond Engineering, Inc. (defense electronics) and Teleco Oilfield Services, Inc. (provider of measurement-while-drilling services to the oil drilling industry), both of which are public companies."—*S.K.* (Co-secretaries: **Marc S. Gross**, Winding Road Farm, Ardsley, NY 10502; **Allan C. Schell,** 19 Wedgemere Ave., Winchester, MA)

Letter to the Editor

An embarrassing error appeared in the August/September 1983 Review's deceased list. Sometimes class secretaries will go to great lengths to get news about their classmates, often threatening to make up something. However, no secretary can be blamed for this one. We extend our apologies to **James E. Tillman, '58.** *Good-humoredly, he makes a persuasive case for his status as living:*

It was with sadness that I read of my demise in *Technology Review*. Fortunately, the report is incorrect unless you consider my demise to be associated with many years of research in the Viking Mars program which can lead to the feeling of being "extra terrestrial" at times. This report led me to wonder if I forgot to make a contribution this year and that you consider this just retribution for my neglect. However, since this has been a poor year for the nation's economy, as well as many individuals, and that I generally contribute each year, I do not think you would go to these lengths to remind me. Since I am a meteorologist, at least by degree, I assume you would exercise more than average caution not to greatly offend my spirit least I curse you with heavy snowfall in Boston at rush hour combined with a year of mud and ice during ski season in New Hampshire. (If it seems unlikely that I can carry out this threat. I might be able to have my meterological friends in the department issue a bad forecast in my honor!)

Since neither I nor my spirit have communicated lately, we would like to inform you of a permanent exhibit at the Smithsonian's National Air and Space Museum. Included in the exhibit is a computer driven high speed graphics/image processor. Along with driving the display, the computer is used for planetary research by the museum staff. Were it not for the loss of the lander in 1982, we would be providing live from Mars pictures and weather data weekly. In any event, U.S. citizens can be proud of the technological triumph of the Viking mission staff since the lander provided data for 2,245 Mars days instead of the expected 120. It is my "spiritual" desire that we visit Mars again in the near future, land on the surface, and physically take part in the journey. This could be an international undertaking that would challenge and excite all of the human race, especially the children of this decade.

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The May 13, 1983 *Daily Hampshire Gazette* of Northampton, Mass., reported that **Virginia Thelin**, a missionary of the United Church of Christ in Taiwan was to speak at the Hatfield Congregational Church. Virginia was a Course V (chemistry) graduate, and she also holds a master's degree in public planning from George Washington University. She has been teaching and doing research in public planning in central Taiwan since 1966. With her husband, Mark, she has carried out social and land-use research in the Taichung Harbor new city area for several years. She is also the Central Taiwan student advisor for the Foundation on Scholarly Exchange, which arranges for graduate fellowships and professor exchange with American colleges and universities.

I am sorry to report the death of our classmate, **William H. Coghill**, on December 24, 1982. Condolences may be sent to his wife, Dorothy, at 1111 Fifth Avenue, Sebring, FL 33870.—**Vivian Warren**, Secretary, 156 Northrop Rd., Woodbridge, CT 06525

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It's been a very quiet summer and fall on the mail front. A note from **Don Straffin** reports that he has been transferred to Bedford, N.H. and that he loves living back in New England. His wife, a medical technologist, is working at the Catholic Medical Center in Manchester. Daughter Teresa starts at Keene State College this year. Don says he became a grandfather (!) in May 1982.

Ben Zarren, our class president, tells me that a group of '61ers got together in Farmington Hill, Mich. with Brenda and **Ira Jaffe** to celebrate their son David's bar mitzvah last August. Most of the attendees were fraternity brothers who had used a small investment club to maintain their friendship for the first couple of years after graduation. The investments were not that great, but they served a purpose and kept the group together. So there they all were, from all over the world, back together in darkest Michigan: Rachel and **Hiam Alcalay** from Tel Aviv, Sherry and **Jerry Goldman** from Deerfield, Ill., Linda and **Will Keningsberg** from Saratoga, Calif., Phyllis and **Howard Rubin** from Oak Park, Ill., Georgianne and **Ken Singer** from Eugene, Ore., Judy and **Mannie Smith** from Norfolk, Va., **Clement Venturi** from Paris, Joan and **Mike Wechsler** from Pleasantville, N.Y. and the Zarrens from Belmont, Mass. It sounds like some recent movies . . . a look back at the sixties. Are any other large reunions going on out there?

Now that I'm back at the Institute, it is fun to compare the place with the way it was back in 1961. For one thing there are a lot more women around. Perhaps I'm getting to be a dirty old man, but they seem a lot prettier than I recall Tech coeds of the past. They seem to swear a lot more, too. Otherwise, the place seems to be about the same—confused tourists asking where 26-100 is, bemused graduate students looking vacantly off into space, the hourly mob scene in the "infinite corridor," and the wierd group of Tech hackers pulling off some strange stunt on top of the dome. Some of the same people are still working in the Coop and wandering around the corridors. The place still seems to be an overgrown high school. I'm delighted to be back.—**Andrew Braun**, Secretary, 464 Heath St., Chestnut Hill, MA 02167

62

We have several new vice-presidents in our class. **John Cozzolino, Jr.** reports that he has changed jobs from being a professor at University of Pennsylvania to being vice-president, Financial Research and Planning Division of Fred S. James and Co. in New York City. . . . **Eugene Finkin** has been appointed vice-president, Operations of Danly Machine Corp., Chicago, a subsidiary of Ogden Corp. . . . **Dwight Kellogg** has been elected a vice-president of New York Telephone and will assume the position of comptroller when it severs its affiliation with AT&T. . . . **Darold Rorabacher** has been promoted to vice-president and chief engineer for the Federal Systems Group's Surveillance Systems Division of Sanders Associates, Inc.

A news release tells of the formation of a new company, Data Recording Systems, Inc., headed by **David Spencer**. The company is located in Hauppauge, N.Y., and will introduce a high performance page printer for the graphic arts and computer-aided design markets this year. . . . **Richard Orr** writes that he has been with the McLean, Va. office of Stanford Telecommunications, Inc. as technical director for the past six years. He and his wife, Julie were married in April 1980.

I received a proposal for a continuing education course in parapsychology from **Victor Schneider** in Boston. The course includes exercises and demonstrations of ESP, past-life regressions, psychic energies, methods of promoting healing, and other topics. . . . **Jerome Yavarkovsky** writes that he has been appointed dean of libraries at Adelphi University, Garden City, N.Y.—**John Prussing**, Secretary, 2106 Grange Dr., Urbana, IL 61801

63

An almost-bare mailbox this month, so let's get right to it. **Matthew T. Mason** is one of the editors of a new book from M.I.T. Press, "Robot Motion: Planning and Control." Good luck with sales, Matthew.

I promised to elucidate my views on the world's problems if I had no news to report. Well, you called my bluff. I really don't have any answers or even any good formulations of the problems. I was thinking, though, that with all the brains in our class we might be able to come up with something useful if we pooled resources. These columns usually just report class news, but what if '63 had a roundtable? We have about 500 words each issue—what if half of that were devoted to pithy comments on problems like, say, how engineering and science interact with societal interests? Take October's *Technology Review*, for example—it has an interesting article saying that fusion reactors are too impractical and too expensive the way they are presently being designed (with deuterium and tritium) to replace coal or fission. But a fellow wrote in the same month's *Scientific American* that fusion is just great. Here we have conflicting views from eminently qualified professor-types on each side. How is a member of Congress supposed to figure out whether to spend public money on D-T fusion, lithium fusion, small fission machines, coal, solar, what-have-you?

The President has science advisors, but it's really Congress that is supposed to set policy. There are few scientists and engineers in Congress, so members have to depend on people with special interests—lobbyists—to digest technical information for them. Any ideas on how a Congressional science and engineering office might work, and whether it could be put together without allowing a lot of special-interest influence? While you're thinking about it, keep in mind that it's worse in the state legislatures, because they only meet a few months a year and have problems just as tough. For example, in my state they're trying to figure out whether Chesapeake Bay is dying, and if so, what to do about it. (How do you give a state funeral to a bay?)—**Phil Marcus**, Secretary, 2617 Guilford Ave., Baltimore, MD 21218

66

1984 is off to a very inauspicious start. Last month no column. This is not because the secretary was asleep or doing his Christmas shopping early. Nobody wrote! This month produced less than half the normal number of news items. If you want to see a column here, you have to send in news.

David Wyss has been appointed vice president

For outstanding service to M.I.T., recipients of the 1983 Harold E. Lobdell Class of 1917 Distinguished Service Awards are (from left): Viguen R. Ter-Minassian, '64, C. William Carson, '52, Christina Huk Jansen, '63, Carol C. Martin, '77, Philip H. Dreissigacker, '37, Lita Donnelly Nelsen, '64, William N. Hosley, '48, Sumner Hayward, '21, and Kenneth Armstead, '75. Awards also went to James E. Cunningham, '57 (posthumously) and Hector M. Orozco, '45 (not shown). (*Photo: Scott Globus, '84*)

and chief financial economist for the United States Economic Service of Data Resources, Inc., in Lexington, Mass. . . . Congressman **Don Ritter** has written an article in *Engineering Times* calling for the organization of Technology Advisory Councils. It is his contention that such organizations could have a very favorable influence on the political system by providing the best possible technical information and recommendations to legislators on the impact of proposed legislation on the economy, social systems and the environment. If you would like more information or wish to exchange views, please write to him at the House of Representatives in Washington, D.C.—**Joe Shaffery**, Secretary, 34 Hastings Dr., Ft. Salonga, NY 11768

67

We had the pleasure of having dinner recently with Ginger and **Ed Radlo** and their daughter Heather. Ed has been promoted to patent counsel for Ford Aerospace and Communications. In addition, he remains as senior attorney for Ford Motor Co. . . . At last report, **Richard Cunningham** was running for mayor of Stamford, Conn. Richard, who has a law degree from Duke University, was a Connecticut state senator from 1978 to 1980. He is married and has eight children.—**Jim Swanson**, Secretary, 878 Hoffman Terr., Los Altos, CA 94022

70

Stanley Eiger has been promoted to account underwriter with Prudential Insurance Co.'s Eastern Home Office in New Jersey. He and his spouse, Caroline, live in Ironia, New Jersey. . . . **David Koh** has joined the courtesy medical staff of J.B. Thomas Hospital in Peabody. After serving an internship at Beth Israel Hospital, he did a cardiology fellowship at the University of Washington and is a fellow member of the American College of Cardiology. . . . **Bradley Williamson** is working with Seattle's oldest architectural firm. He is in the process of renovating an old house along with the help of his spouse and his two daughters.—**Robert O. Vegeler**, Secretary, Dumas, Backs, Salin, and Vegeler, 2120 Ft. Wayne National Bank Bldg., Ft. Wayne, IN 46802

73

A thin month for news this time, but I did get a note from the **Ed Fenster-Machers** that Carol had given birth to daughter Erica on August 17. All are sleeping through the night.. . . **Tom Ellis** and wife also were fruitful and multiplied, with S. Matthew being born on September 21, 1982.

David Reed has joined Software Arts of Wellesley in a full-time development position directing a research and exploratory development group with the creators of VisiCalc. The blurb from P.R. wasn't specific on Dave's tasks, but they sure like him.

Chapel Hill (our home, not the hometown), at this date has footings and block in process. As you read this, we better be in it, by gum! Eric is now 10, the baby (?) almost 3 (got to stop calling JR a baby), and Ruth never looked younger (I know she reads this).—**Robert M.O. Sutton**, Sr., 24 Princess Anne Ct., Warrenton, VA 22186

74

Happy new year. So, we made it to 1984 without *1984* coming true. Keep your eyes open anyway. Orwell's vision might have hit a scheduling snag.

Joy and **Marc Lauritsen** have their first-born as of March, a daughter named Whitney Elsa. Mark has been appointed director of clinical programs at Harvard Law School.

Deborah Ruppert and **Paul Mailman** sent me a note announcing the arrival of their son from El Salvador, Eduardo Ruppert Mailman, age 2. To quote from the note, "Eddie is doing fine. His parents are suffering from terminal exhaustion. It's been a long, rocky road to this our first child, and starting with a 'terrible 2' isn't easy. But somehow the big grin, the extended arms, and the gleeful shout 'Papa!' make it worth it."

Our 10th reunion is coming in early June. This is the BIG one (until the 25th, that is). Start your diets *now*. And send news, notes, gossip.—Co-Secretaries: **Lionel Goulet**, 21 Melville Ave., Dorchester, MA 02124; **Jim Gokhale**, 12 Pond Lane, No. 54, Arlington, MA 02174

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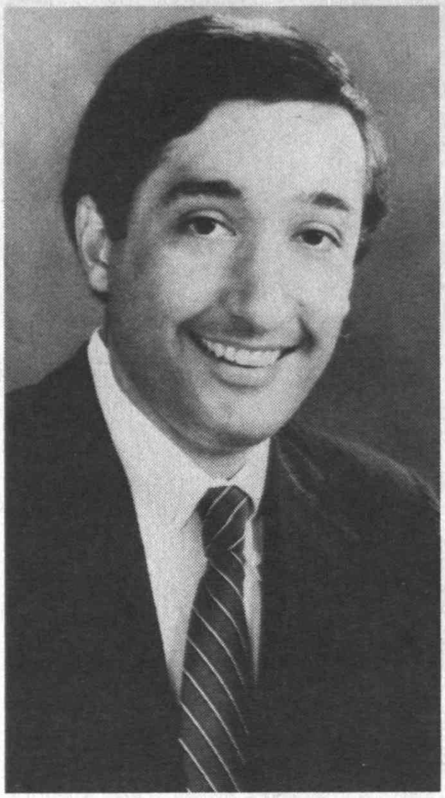
Steve Slesinger is in Melbourne, Fla.: "I married in 1981. Shelly and I went to San Diego for a vacation and saw a fellow alumnus and good friend, Manuel Malagon. I'm managing the development of large ($30 million or so) software system at DBA Systems, Inc. Our first child, Sarah Michelle, was born March 8. *That* is really an education!". . . **Paul Adler** is studying martensitic transformations in plutonium metal at Lawrence Livermore National Laboratory in California. . . . **Richard Epstein** completed his first year of medical school at Yale University. He has started his own computer software company.

Keith Milkove says, "Alas, I've been denied student tenure at Cornell. I will unceremoniously terminate my Ph.D. studies by finishing my thesis some time before the end of 1983." Student tenure? An interesting concept. . . . **Rick Shafer** has finished his Ph.D. in Physics at the University of Maryland. "Subtitle of thesis, 'Waiting for the X-ray Background' says it all. All and sundry should know that I am no longer officially incommunicado (i.e., I can now have fun once a week). I am about to start a one-year limited engagement at the Institute of Astronomy, Cambridge University. Visits welcome. On the other hand, I would like to get in touch with someone in London." . . . **Paul Siegel**: "My enthusiasm about living in California and working for I.B.M. Research continues to grow, right along with the price of a share of I.B.M.



Mayor Cisneros Moves San Antonio Into the High Tech Era

San Antonio's young Mexican-American mayor, **Henry G. Cisneros, '76,** is proving wrong that adage that "them who can, do; them who can't, teach."

At age 36 he is both teaching urban issues and solving them and in the process has become one of the hotest political properties in the country. He is blending a scholarly background with native political instincts to push this southwest Texas city—and himself—forward.

When he was first elected in April 1981, he became the first Mexican-American mayor in San Antonio in modern times and the first of any major U.S. city. When he was reelected in 1983 by 94 percent of the vote, his leadership was affirmed.

He promised an administration geared to economic development, one that would expand the economy of the city and help the poor and the underemployed, not through handouts but through jobs. Toward that end he has embarked on a program to try to make San Antonio a center of high technology for he is convinced that is where the future lies.

stock. Last year was an interesting one. My research in signal processing and coding led to a first-filed patent and the opportunity to present a paper at the InterMag conference in Montreal. Besides logging bit errors, I also logged miles. Last May I ran the Avenue of Giants Marathon, my first, in the beautiful Humboldt redwood forest; I managed to survive even the six-hour drive home: clutch, shift, cramp. . . . Masochist that I am, I followed with the San Francisco marathon in July, where my companions and the refreshments made it all worthwhile. Got to run . . . ."

Elizabeth Zahniser and her husband David, '73, had twin boys—Russell Joseph and Michael Robert—on March 2, 1982. "They've kept us busy, and we are enjoying them immensely. I am a full-time mother of twins, but manage to take guitar lessons and help a group of Lutheran students at Wellesley College." Her husband, David, is assistant professor at Tufts New England Medical Center, doing research on biomedical imaging and pattern recognition. . . . Our classmates **Caryn Navy** and **David Holladay** (who are married to each other) were mentioned in an article in *Tech Talk*. David has developed a machine for the blind known as Braille-Edit. This is a computer-based text editing device that uses a refreshable braille display. Initially it was intended for Caryn, who is now an assistant professor at Bucknell University; but it obviously has wide applicability, so David has started a company, Raised Dot Computing of Lewisburg, Pa., to distribute the machine. . . . **Kathleen Zimmerlin** is now Kathleen Zimmerlin de Paz. She married A.J. Paz, whom my informant describes as "the most wonderful man in the world," on January 8, 1983; they spent their honeymoon in Cancun, Mexico, "visiting incredible archeological sites and ordering rum and cokes por favor." Kathy has an M.B.A. in finance and urban land economics from U.C.L.A. She works for an aerospace firm developing a new manufacturing complex and updating their master plan, all part of her duties as staff architect. Her husband, a civil engineer/attorney, works for another aerospace firm. They live in Los Angeles in a house close to the beach, together with two "purebred alleycats," two "dog-pound refugees," and a "combined library that spills all over the house." For relaxation they enjoy working in their rose garden.—**Alex Castaldo**, 929 Massachusetts Avenue, Apt. 12D, Cambridge, MA 02139

76

Your secretary had the pleasure of shocking **Mike Sarfatti** with a phone call from Hong Kong. Mike is still happily living atop Russian Hill in San Francisco and enjoying the California lifestyle. He was also able to give me an update on **Steve Issac**. After the 'Tute, Steven went to Berkeley for an M.S. in Chemical Engineering. After Berkeley, Steve worked for IBM for a while and then spent 18 months travelling in Europe and Israel, from December 1980 to April 1982. While in Israel, he lived on a Kibbutz. After all of the adventuring, Steve can be found in Boulder, Colorado, where he is the project manager for a government-related agency involved with solar energy R&D.

I will be calling classmates to obtain news as the mail has been, to date, non-existant. I hope that will change in time. As for the commodity markets, the U.S. dollar, interest rates, and gold continue to provide violent arenas. And the grain markets have had an amazing summer and fall, with no end in sight. We never lack for activity in this business.

On a personal note, I have moved out of my hotel and taken an apartment. I am in what is known as "Mid-Levels" which is approximately half way up Victoria Peak. The view of the harbor and Kowloon is simply breathtaking. Hong Kong is a lovely city, especially spectacular at night. I will try, in subsequent issues of the notes, to provide vignettes of life at the cross-road between East and West.

Please do write—the postage is only 40 cents per ounce, which is still a bargain. When you do, please include a phone number and time slot and I will give it a try. The only request I have if I call you during business hours is not to put me on hold!—**Arthur J. Carp,** Secretary, 71-73 Robinson Rd., 9/F Flat 5B, Hong Kong

77

Steven R. Bader is currently practicing in and managing a large group practice in Burlington (Vermont, I presume?). He recently met with his brother Jamie '80, as well as several Pi Lam brothers, **Mike Barrett, Rich Scheuermann**, and **Kevin Trammel** at Lake Tahoe for some wonderful skiing. . . . **Esther Horwich** is still practicing law in downtown Boston. In her spare time, Esther plays bass trombone with the Metropolitan Wind Symphony. . . . **Carrie Galehouse** graduated from Harvard Business School in 1981, and is now with Bain and Co. as a management consultant in Boston.

I will try to find a substitute secretary for the February/March issue of *Technology Review*, but if I do not, I may miss an issue due to my travels to Japan in November. Please forgive me if that happens, and WRITE so that I will have more news to report. Thanks.—**Barbara Wilson Crane**, Secretary, 6431 Galway Dr., Colorado Springs, CO 80907

79 — 5th Reunion

Happy 1984 to all! This is the year of Big Brother—have you checked over *your* shoulder lately? Enough small talk . . . On to the news.

Karl Kortepeter had a busy 1983. On June 25, he was married to Tami Jenkins. Tami is a page supervisor at ABC, assisting with audience control on "9 to 5", "Happy Days," and others. She also attends California State University part-time, and is finishing her senior year in speech communications (Department of Radio, TV, and Film). Karl, in the meantime, left the Air Force on August 10 and started Loyola Law School. He writes, "Our wedding was quite beautiful and we hosted 200 people

Writing in his limited spare time—at nights and on plane trips—he produced a 242-page report on high technology and how San Antonio can fit into the picture. It was widely distributed among the power structure of the city for review and, following national publicity, the report was requested by cities across the country and abroad. So far nine computer-related industries have located in the city, which has a large and trainable work force, lots of space, and plenty of energy.

Another significant document by Cisneros, "Goals for San Antonio," has grown from a list of 180 projects into a major planning force. More than 400 citizens organized into committees are reviewing and refining projects that will constitute municipal efforts until 1990—the first citywide goals program ever experienced by San Antonio.

Cisneros makes a living by teaching a part-time load in urban studies at the University of Texas at San Antonio, where he convinced the board of regents to add an engineering school to the curriculum. (And, he was the major drive behind opening a high tech high school last fall.) Inasmuch as San Antonio has a council-manager form of government, under which a paid administrator manages the city while the mayor and council set policy, Cisneros is entitled to only a token salary of $4,040 a year. Because state law prohibits a public official from accepting two government salaries he can't draw the $4,040. He supplements his modest UTSA salary with fees from lectures and he is becoming more and more in demand as a speaker.

While teaching and study are loves, politics is a passion and Cisneros already is being talked about as a statewide candidate for the U.S. Senate or governor although no Mexican-American has ever held either position. President Reagan has twice named him to participate in fact-finding commissions of national importance: the President's Commission on Federalism and the Bipartisan Commission on Central America headed by Henry Kissinger.

"Henry Cisneros is the most electible Democrat statewide in Texas today," says George Shipley, an Austin-based political consultant and pollster. "He's the most exciting politician of any political part in the Southwest."

Despite his popularity the Cisneros administration is not without controversy, particularly over the city's participation in a $5.5 billion nuclear power plant. San Antonio, which owns its gas and electric system, is a 28 percent partner in the plant, known as the South Texas Project. It is over budget and behind schedule and some critics are calling for San Antonio to get out of it. However, Cisneros remains firmly behind the project, saying it is in the city's best long-term interest.

So far Cisneros has taken the media attention he is getting and the speculation about his political future in stride. He says his only objective right now is to be the best mayor he can be for San Antonio.

"My plans are to make San Antonio a major league city. I hope to be mayor for as long as it takes to reach those goals," he says.—*Jim Wood*

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at our wedding reception. **Peter Arndt** was one of my ushers. Tami and I went to Nevada City, Calif., in the heart of the gold mining region, for our honeymoon. We stayed at her uncle's cabin (actually a two-bedroom house) on a secluded mountain above a lake. Some of our day trips took us to Reno and Lake Tahoe. We finished our first days together at Yosemite National Park, where the scenery was awesome." . . . **Jésus Alvarez** married Rosa Maria Lopez (Mt. Holyoke, '82) in December 1982. The happy couple reside in Boca Raton, Fla. Jésus has been working for two years in IBM's Industrial Automation Group in the development of industrial robots. . . . Good luck to all the newlyweds!

Andrew Saschère says, "Greetings from beautiful downtown New Brunswick, N.J., where I'm called doctor and asked to touch and poke total strangers in all sorts of ways!" Andy just graduated Rutgers Medical School in May, and is doing his residency in family practice. He reports that **Dave Miller** is "getting paid for fooling around with a computer and being a 'research engineer' for U.R.S. Blume and Associates in San Francisco. I recently imposed myself on Dave and wife Naomi Miller, '78, in Berkeley, where I saw snowy Yosemite National Park in June." Andy also reports that "**Hubie Blumenfeld** is living it up in the East Village and playing original guitar songs at the Music Coop and Speakeasy on MacDougal Street."

Jacqueline Buckwald was born on May 22, 1983, to **Michele Buchwald** and Gary Buckwald, '76. Jackie's big brother Benjamin is already 2 years old. Michele works part-time as an actuarial associate for John Hancock in Boston, while Gary is manager of technical support at Analog Devices in Norwood. . . . **Esther Jaffe** and Jeff Jaffe, '76, also had their second child in May—a bouncing baby boy named David. Congrats to all!

As for yours truly, I am enjoying my job as a telecommunications analyst with Mobil. I am trying to become the local guru on teleconferencing. My so-called spare time is moving at breakneck speed, as usual—two dance classes, a comedy/improvisation workshop, spotlights and costumes for the latest St. Bart's Players musical, chairman of the M.I.T. New York Alumni Association's 1983 Fall Telethon, and occasionally something called sleep! Hope you are all busy, too. (From the amount of mail I have been getting, you must be!) Bye for now.—**Sharon Lowenheim,** Secretary, 131 E. 83 St., Apt. 2G, New York, NY 10028

81

Before we get going this issue, a couple of announcements. First, thanks to **Lew Bender** for serving as our class's first Guest Columnist last month. The offer is still open to everyone: for one month I'll send you all the stuff I get and you can do a column for *Technology Review*! All the fame and glitter without the nagging long-term responsibility. Please write if you're interested. Second, *Technique*, the M.I.T. yearbook, has a few 1981 yearbooks available at $15.00 each plus $2.50 postage. If yours has been misplaced, lost or burnt (or you forgot to buy one), you can contact the business manager at P.O. Box 5, M.I.T. Branch, Cambridge, MA 02139.

Here's a nice letter from **Gene Becker**: "I'm living a wonderfully decadent lifestyle here in Silicon Valley, working for Huey-Packard and growing older but hardly wiser. I just got home from an H.P. product release (and raw oyster) function, also attended by ex-grad students Tom Lee and Mickey Lee (no relation) and **Lisa Parechanian**." . . . Lisa also wrote me a note recently. Apparently your humble class recorder mistakingly said that Ms. Parechanian was attending U.C.L.A. Well, Lisa is at Berkeley, and as Lisa puts it: "Berkeley is Berkey and U.C.L.A. is U.C.L.A., and never—not even with a *huge* earthquake or Dukemajian's education cuts—the twain shall meet!" Lisa also points out that "'Beefcakes' are served at fast food restaurants, but there are a lot of cute guys here." Do you readers ever notice the state of mind these Californians are always in? And people wonder why I'm applying to Stanford. . . . Also heard from another McCormick 6th Wester besides Lisa, **Lauren Christopher**, who writes, "Hello to everyone (especially to the McCormick 6th Westers). I have had the terrific opportunity to spend six rainy months in Hamburg, Germany. I was working on a digital TV project for RCA (with Philips). I met some really nice people and had great fun! Former 6th Wester Nancy Saraf was over for a week or so to travel with me. I'm glad to be back and (finally) settled down in New Jersey."

If any classmates are in need of an attorney, **Van Gallagher** is "finishing my last year of law school at University of Texas at Austin; hope to practice in Texas, specializing in criminal law"—although I hope nobody from our ranks is in need of that type of legal advice. . . . **Jeff Menoher** writes, "I've completed one year of teaching physics in Mamaroneck, N.Y. True to the bearer tradition, I took a bunch of chemistry courses and have satisfied course requirements for medical school. Also, Kurt Johnson, '82, is in Greenwich, Conn., working for U.P.S. Our local women must now be chaperoned." . . . **Paul Miller** writes, "I have started my own business, called Infotouch Communications Corp., with classmate **Bob Anderson**. We have offices in Cambridge, Mass. and Chicago, Ill. Our company designs and builds touch-sensitive gas-plasma displays. We are also an information network." Sounds pretty interesting, Paul.

As for *moi*, the quintessential renaissance man still lacks a degree from this hallowed institution. Efforts to correct this deficiency are under way. I would also like to have a few other random folks volunteer to do guest columns. I'm telling you, you don't know what fun you're missing. Seriously!—**Chuck Markham**, Secretary, 362 Commonwealth Ave., Apt. 2E, Boston, MA 02115

82

The postcard-of-the-month contest is back—with two entrants this month. **Helen Fray** sent me a beauty of the Ramada Inn on the New York thru-

way near Kingston, N.Y. Helen writes that she transferred from I.B.M. San Jose to I.B.M. Los Angeles. She's moved over to marketing technical support from her previous position as a manufacturing engineer. She'll be marketing graphics systems—CADAM, CAEDS, CATIA, and CBDS. (Who knows what all those initials mean.) She says it's been raining. (I guess she means it's been raining in New York while she's on a business trip there, since all of us in the East know that it *never* rains in California.) . . . The other postcard this month is from **Gerard Weatherby**. He sent me three (quantity over quality?). It's a Saratoga Springs Series: We have the thoroughbreds at Saratoga, the museum antiques and arts at Saratoga, and the Adirondack Trust Bank Building at Saratoga. Gerard's now at Submarine School in New London, Conn.

Michael Cook is a research engineer at Exxon Production Research Co., and his wife Rosanne is a licensing engineer for Bechtel Energy Corp. . . . Congratulations to **Lisa Greenfield**, who is engaged to **Jeffrey Borenstein**. Last May, she got her M.S. from Sloan, and she's now working for Chemical Bank in New York.. . . **John Hollis** made it to veterinary school! He's at Tuskegee Institute in Tuskegee, Ala. As John says, "Don't forget, hire a vet!"

Most of my time these days is spent studying for the actuarial exams. I study more now than I ever did as as student (of course, that's not very hard to do). I was feeling like a real nerd until I found out that John Hancock sponsors a tutoring program with Boston English High School. Two days a week, I'll be taking an extended lunch to go over to the school and help international students learn English as a second language, and I hope to start helping students there with math too. On the Institute side of things, I had the pleasure of attending my first M.I.T. Corporation meeting. We spent the afternoon at the dedication of the E.G.&G. Building. Doc Edgerton told some pretty good stories, a lot of ribbons and cake were cut, and the E.E. department got some badly needed new facilities. It's the kind of day that's hard to complain about. Write or call if you're in town (I'm in the Cambridge phone book).—**Rhonda Peck**, 38 Bigelow St., Cambridge, MA 02139

83

Hello again fellow classmates. I have yet to receive any letters from anyone in the Class of 1983. I suppose it's because the deadline for the second article came before our first class article was ever published. I, however, was not going to let something as minor as not having letters affect my article writing capabilities. I shall just rely on gossip and out-and-out lies.

To start with, **Caren Baker** has accepted a job with Knoware, Inc., a new company started by J.J. Donovan of the Sloan School of Management. Caren says she is very excited and is looking forward to playing with pointers in C. . . . **Doug MacPherson** tells me he is engaged. His fiance is in Louisiana applying to medical schools. He misses her terribly. Hang in there, Doug. . . . I ran into **Ken Dumes**, who informed me that he is making a run for the Class of '84 president. He says if he wins he will have more than enough experience to take part in the mayor's race.

There are a few people in our class who have already tied the knot. I do not remember them, but it will be a project for my next article. . . . As for myself, I am currently working part-time for Knoware, Inc. doing product design and marketing. I am also playing on M.I.T.'s football team, which is doing well. We are presently 3-2. We have won our last three games. Besides classes, I am trying to complete my thesis.

Well, good luck out there. Please keep the letters coming. Should the letters continue at the present pace, I shall be forced to have class note highlights—completely fiction of course.—**John De Rubeis**, Secretary, 86 Mount Vernon, Boston, MA 02108

Alumnus Tells First-Hand Grenada Story

The following is from a column in Tech Talk *by Robert C. DiIorio.*

An M.I.T. education offers a superlative preparation for a variety of situations, but how to deal with revolution, insurrection, war, and being caught between opposing armed forces just wasn't in **Bruce Levy's, '82,** Course V syllabus.

Levy faced all of those perils recently in Grenada where he was a student at St. George's University School of Medicine. He was among those students who wanted to leave the island shortly after the overthrow of the government.

Levy said it was his impression that at least half the students wanted to get out. The university, however, was "trying to convince us to stay." He lived off campus with another student, about three-quarters of a mile from the university. His 500 Grenadian neighbors included many university employees, and several of them, he said, advised him to leave.

On the day the U.S. forces arrived (October 25) Levy and his friend remained in their house most of the day listening to the radio. Radio Free Grenada went off the air, and the U.S. broadcasts began. Levy recalls the text as close to these words: "People of Grenada. United States forces have intervened in your country at the request of your neighbors. Please cooperate by staying in your houses and by confiscating the weapons given to your children."

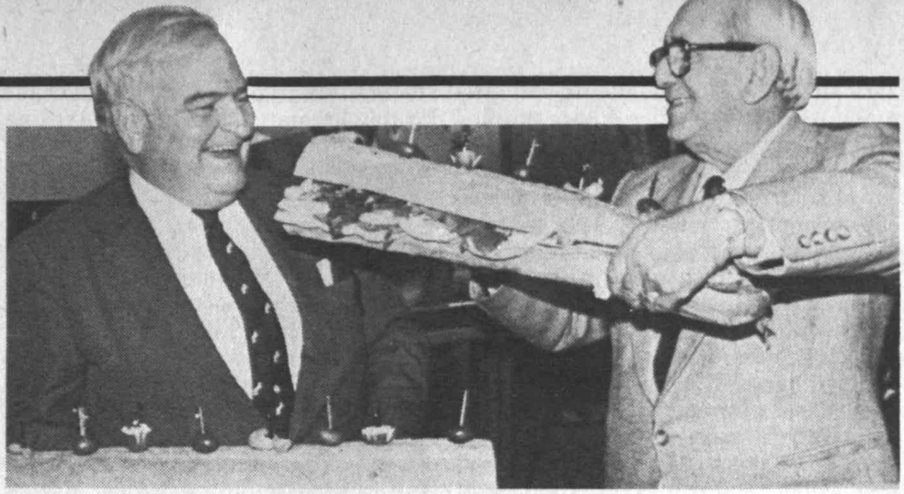
Levy heard and saw bombs and artillery shells exploding. A house about 50 yards away was destroyed by a direct hit. Upon deciding to return to the university, Levy and his friend were surrounded by U.S. soldiers. After checking to make sure we were really students, an officer escorted them to the university.

Several university buildings had been hit by machinegun and rifle fire, he said. Many of the students, Levy included, helped through the night and into the morning at the hospital that had been set up there. "I don't think there's a door we didn't knock down to get at equipment."

The next morning, the military began flying the students out. Levy was on the second plane with about 70 other students. He was taken to Charleston, S.C., where the Air Force had "just about everything we needed—hotel rooms, money, plane reservations."

They were about two-thirds of the way there when the shout rang out: "Halt and identify yourself." Levy remembers seeing many guns pointed at them from behind rocks and catching a glimpse of a man's face, covered with green camouflage. The troops were U.S. Rangers and all their faces were coated with the green material.

Levy, who is hoping an application he has pending at the University of Massachusetts Medical School in Worcester will be acted on favorably, said he would be willing to return to Grenada if that became necessary to continue his medical education. He is hoping that won't be necessary—not because of the situation there, but because he would rather attend school in the U.S.



That king-sized sandwich was prepared for President Paul E. Gray, '54, when he visited "Stories," a new non-profit restaurant on M.I.T. property that will train Cambridge young people for jobs in the food industry. The purveyor is Cambridge Mayor Alfred E. Velluci.

How Well Can You Write?

Write a clear, coherent expository essay for a general reader. Good organization and structure are essential in maintaining a flow within the essay. Support generalizations with appropriate details and examples; pay special attention to grammar, punctuation, and spelling.

The Class of 1987 confronted these instructions for the Institute's first-ever test of writing abilities. Sitting eight to a table in the New Athletic Center, the freshmen were invited to discuss among their tablemates the three designated topics—each had to choose one on which to write—for 30 minutes. Then an hour was prescribed for writing.

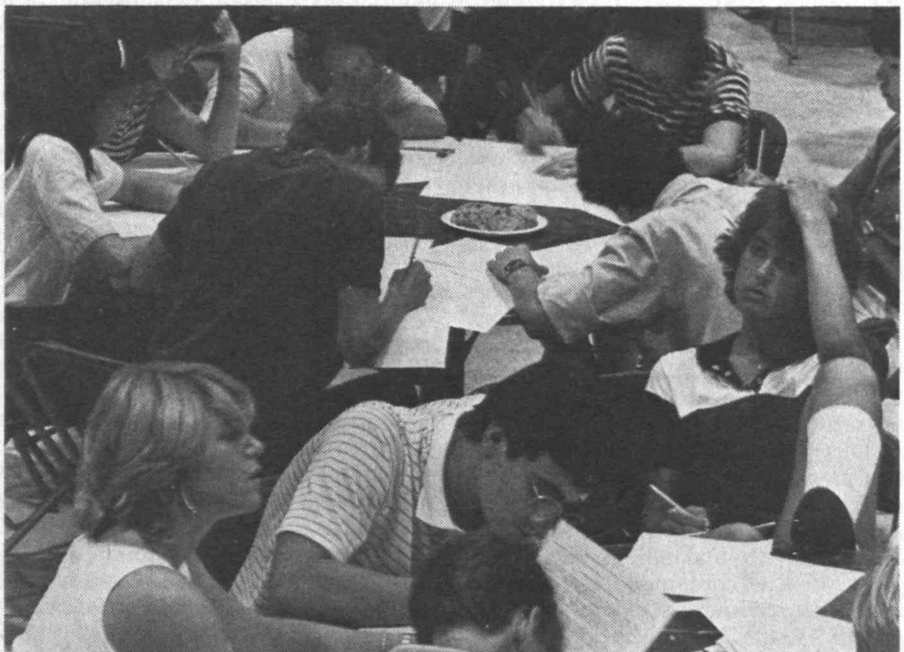
The informal atmosphere was bolstered by a paper plate of chocolate chip cookies on each table, and Professor Arthur Smith, chairman of the faculty, received rousing applause at each pause as he issued instructions: ". . . We believe that good writing is an important part of anything you decide to do," he told them.

Only one complaint: many wanted to write with pen, but pencil was mandatory. A few said they'd have preferred to bring their own word processors.

Approved by the faculty in the spring of 1981 to take full effect with this fall's entering class, the Writing Requirement came into being after a study by the Committee on Educational Policy determined that "a substantial number of M.I.T. students do not achieve a level of writing proficiency adequate for either their course work or their professional careers later on." The committee recommended a requirement "to have undergraduates demonstrate achievement at specified levels of competence in expository writing," and the faculty approved it with almost no dissent at all.

Last year, the exam was given as an experiment to the Class of 1986, and freshman were "strongly urged" to take it. This year, the test was one of three ways for freshmen to demonstrate their literary proficiency. Alternatively, they could submit an acceptable five-page paper or register for one of several writing courses. Given these options over the summer, fewer than 700 freshmen said they would take the exams scheduled during Orientation. But when the time came more than that opted for the test: an unofficial count put the number at close to 1,000. "My guess is that they're marching through the options," said Bonnie Walters, coordinator for the Committee on the Writing Requirement. "If they pass this, they don't have to the write the paper or take a course."

The essays are being read by a group of evaluators which includes among others Ms. Walters, President Paul Gray and Provost Francis Low. Priority in reading was given to essays from students who were expected to do poorly, as determined by the quality of the writing in their admissions applications, so as to give them an early chance at a writing class. It was expected that about



PETER MUI, '82

Nearly all of M.I.T.'s freshmen opted to take a writing test at the start of the term, and fully 40 percent of their essays were judged unsatisfactory by faculty readers. That failure rate was one-third higher than expected, and writing classes are bulging.

25% of the freshmen would fail the exam, a comparable percentage of failures to last year. However, as the evaluation process continued the percentage of failures rose to 40%, with another 30% marginally passing. Ms. Walters discounted the theory that the exams were being more harshly graded as a reason for the higher failure rate. "I'm really puzzled," she admitted.

Each student is advised on the status of his or her essay by interdepartmental mail; those who fail or marginally pass are asked to make an appointment to see Ms. Walters. "They've been very good about coming in; since the start of the term I've seen about ten freshman a day," she says. Their reaction to being told that their writing is substandard has also been very good, she reports. "They understand that writing well is to their benefit and are willing to take whatever measures are offered for improvement." While undergoing formal processes to satisfy the requirement, students are urged to stay aware of the Writing Program Office and the Writing and Communications Center, both of which offer seminars and individual consultation on writing problems.

In anticipation of the additional enrollment in its courses, the Writing Program expanded the number of sections in expository writing from five to twelve, for an additional capacity of about 100 students. "Overall, I'd guess that the requirement will expand the Writing Program 15 to 20 percent," says Professor James Paradis, who is overseeing the transition, "adding about 200 students to the number taking writing courses each year."

For some students, failure was taken with grim acceptance. "Do you know what it's like to fail your first test in college?"

"Don't worry," consoled a passing upperclassman, "you'll have many more opportunities to feel that way."—*Peter Mui, '82*

Record Giving and Investment Gains Outshine a $3 Million Deficit in 1982-83

With total expenses of $588.7 million in 1982-83, M.I.T. had a deficit of $3.1 million, well below the $4.4 million projected as late as April 1983—but well above the $2 million deficit of 1981-82. The shortfall between revenues and expenses was met by use of an income reserve fund.

But the two highlights of M.I.T.'s financial performance in fiscal 1983 were the record total of gifts and the outstanding performance of the Institute's investment portfolio. Glenn P. Strehle, '58, treasurer, writes that 1982-83 was "the most remarkable year for asset growth in the Institute's history."

This year's deficit is different in source from those of a decade ago, when M.I.T. first experienced expenses in excess of revenues, say Strehle and Stuart H. Cown, vice-president for financial operations. The earlier problems represented "a structural imbalance caused by differing rates of growth in expenses and revenues." In contrast, this year's deficit is attributed chiefly to discretionary expenses for upgrading academic and research facilities. That M.I.T. chose to make them reflects "the expectation of continued growth in the underlying financial strength of the Institute," write Cowen and Strehle.

Rising Tide of Gifts

Gifts, grants, and bequests to M.I.T. in 1982-83 reached an all-time high of $50 million, compared with $41 million the previous year. The largest variable was individual giving, with "several of the Institute's alumni and friends making their most significant lifetime gifts."

More than half of these gifts will be used for operations in 1983-84 or thereafter; 22 percent were gifts to endowed funds. The increased giving in this and recent years, Strehle writes, "has allowed the Institute to respond to new initiatives of the faculty that would not have been possible a decade ago."

Investment Successes

There was a large increase in the market value of M.I.T. invested funds—up 42 percent from $539.7 million to $767.3 million in the year. Common stocks and other equity investments increased by 59 percent, and total funds at book value were up from $697.1 million to more than $768.8 million by the end of the year. These funds include the cost of educational plant and realized investment gains, but they do not include the $252 million of unrealized market appreciation on investments.

Two factors behind this outstanding performance, says Strehle:

☐ The year began with financial markets at a low point, from which both stocks and bonds made large gains.

☐ There have been a number of successful investments in venture capital limited partnerships, leveraged management buyouts, and small, privately held companies. And Strehle expresses thanks to members of the Corporation, alumni, and other friends who "have been helpful in identifying and evaluating such financings."

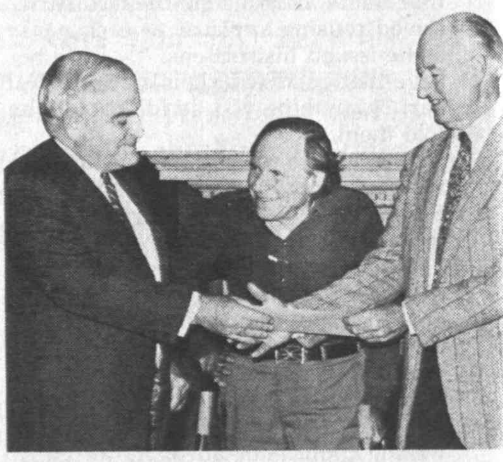
Moving on Microsystems

Building 39, which spans the main entrance and exit from M.I.T. onto Vassar Street, is gutted and being readied for new tenants. Built just 15 years ago to house the Institute's mainframe computers, Building 39's rapid obsolescence is a stunning demonstration of the pace and cost of technological change.

The computers of the Information Processing Center are now tied by wire to their M.I.T. users from Building W91—a remote location at the extreme west end of the campus that would have been unthinkable for such vital machines a decade and a half ago. The supersonic wind tunnel for which Building W91 was originally built is simply gone.

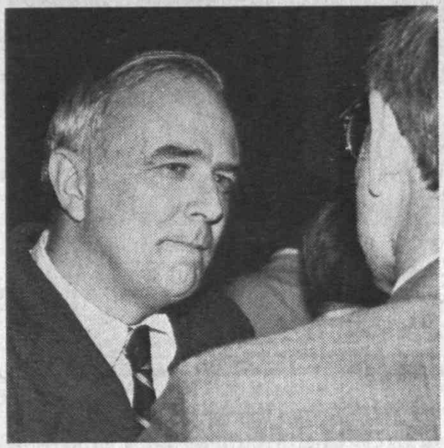
In the computers' place at the heart of the campus are coming the specialized, high-technology facilities of a center for microsystems education and research, including at least $6 million of equipment for fabricating integrated circuit chips.

Completion is set for September 1984, with the total cost $21 million. Already 10 companies have supported the program as members (the latest being a $1 million commitment from Raytheon Co. late last fall), and nine more are also providing support. The work began last year with funds obtained through a bond issue of the Massachusetts Health and Educational Facilities Authority—$25.6 million at a net interest cost to the Institute of 7.12 percent.



President Gray (left) hands the honorarium for the 1983 Killian Faculty Achievement Award to winner Robert W. Mann, '50, Whitaker Professor of Biomedical Engineering, with Professor Philip Morrison, chairman of the selection committee, in the middle. Mann, who is president of the Alumni Association this year, will give two Killian lectures on April 9 and 12.

Honoring M.I.T.'s Congressional Delegation



Six alumni are now members of Congress, and four of them were guests of honor of the M.I.T. Club of Washington at a gala Congressional reception last fall. Clockwise from the top left: Les Aspin, Ph.D. '66, of Wisconsin; Don Ritter, Sc.D. '66, of Pennsylvania and Howard Wolpe, Ph.D. '62, of Michigan; and Bruce Morrison, '65, of Connecticut. President Paul E. Gray, '54 (*lower left*) led a delegation from Cambridge (Photos: Jean Gwaltney)

Activities Participation Down; Are Students Too Busy?

Participation by undergraduates in student activities is down this year, says the Association of Student Activities, and it's especially hard to find students willing to take on the time-consuming but vital leadership roles.

Ellen L. Spero, '86, reporting in *The Tech*, says that the trend is widespread. Already some activities have been suspended or cancelled as a result.

The reason? Increasing pressures on students—to finish early, because of the ever-higher cost of going to school, and to do well, because of the poor job market, thinks Kirsi C. Allison, '84, president of ASA.

"People have to work more hours or they feel a greater stress to get better grades or to graduate in less time," Allison said in an interview with Spero.

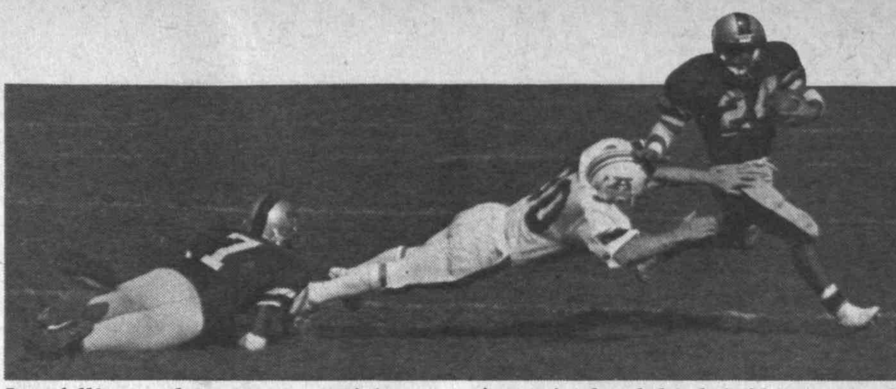
Already the Student Center Committee has discontinued its free weekend midnight movies for lack of a coordinator, and the Lecture Series Committee has cancelled its Classics Series for the same reason.

Julia A. Inde, '84, president of the M.I.T. Musical Theater Guild, says the group has "a definite problem with student participation (this year). . . . People aren't willing to spend that much time on outside activities," she told Spero.

Technique, the yearbook, and *The Tech* are both affected. Suzanne L. Horine, '86, *Technique* editor, says the real problem is with the amount of time students can give, not with the numbers who want to work. "The number of people in the running for the higher responsibility positions, which require more work, has declined markedly," says V.

Michael Bove, Jr., '83, chairman of *The Tech*. The result, he said, is that "fewer people are doing more work."

But Julie D. Forman, '85, president of M.I.T. Hillel, is hopeful. "Activities at M.I.T. aren't doomed," she told Spero. It's simply a problem of selling—"impressing on students that they have a need for what a given activity provides, and then people will make time."



STEVEN WHEATMAN, '86 (THE TECH)

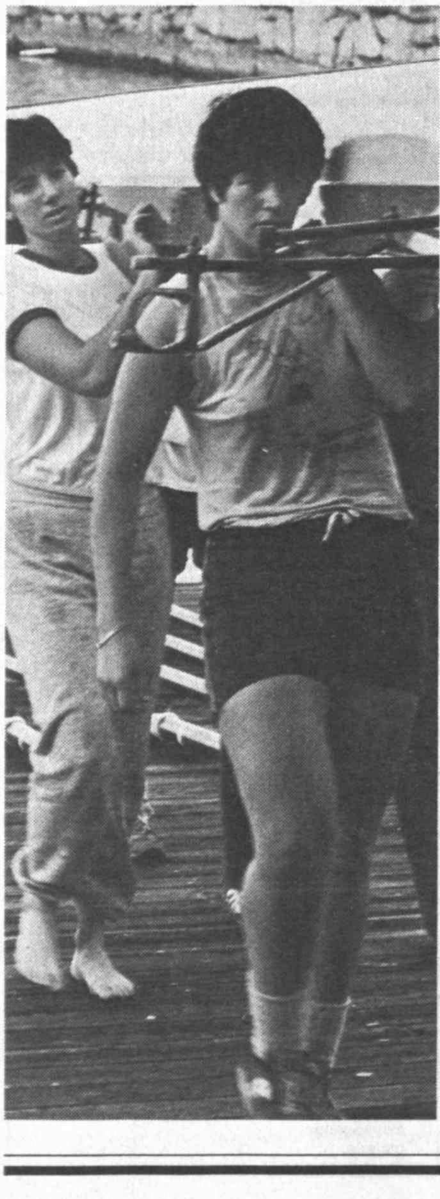
Last fall's was the most successful season in history for the M.I.T. football club. There was a 41-0 win over U-Mass Boston (the largest margin of victory in the club's brief history) and a week later a 35-24 win over Assumption (*above*). That's Fred Allen, '84, carrying the ball.

New Music for Computer

Five new musical compositions for computer composers in residence at the Experimental Music Studio will result from a $40,000 grant from the Massachusetts Council on the Arts and Humanities.

Composer Graham Hair completed his residency last fall, and his new work—12 studies for trombone and computer-synthetisized sound—was premiered in Kresge with Lawrence Isaacson, trombone, on September 24. Hair is an Australian, and he told Richard Buell of the *Boston Globe* that he finds the computer "a completely versatile" musical instrument. "One of its idiosyncratic characteristics is that it *doesn't have any*," Hair said.

Charles Dodge, professor of music at Brooklyn College who is now in resi-



THOMAS A. RUSS COURTESY TECHNIQUE

From Rugby to Rowing: In Quest of Perfection

Elizabeth Bradley, '83, who's now a graduate student in Course VI, talks about going to the Olympic Games the way some people talk about graduate fellowships; she is not counting on it, but it would be nice.

Bradley always wanted to play football. Instead, she came to M.I.T. and chose rugby, becoming team captain by her sophomore year and a member of the Boston Women's Rugby Club shortly thereafter.

Bradley had to quit last year when her doctor told her that she had suffered too many concussions. Bumper stickers that read "Give blood: Play rugby" are not kidding.

The Rugby Club's loss was the crew team's gain. Bradley decided to return to rowing, a sport she had tried briefly in her freshman year. The coach of the novice squad sent her to then-varsity coach Douglas Clark, since she had already learned the basics, until the rest of the novice team could catch up. Clark never gave her back.

A friend of Bradley's accused the coach of brainwashing her. Perhaps he did. "As the [racing] season approaches," Bradley says, "you get totally drawn into it, physically and emotionally. People start calling you a fanatic. The day of a race, you don't want to deal with non-crew. They don't understand. My parents came to see me the day of a race, and I practically threw them out.

"You've run 30 miles a week, lifted weights, spent months getting perfect. The two days before a race you spend peaking. . . . When you go out to the starting line you're terrified. The coach says you look like you want to throw up. The first stroke you're so nervous you forget to breathe."

The training, nerves notwitstanding, paid off. In 1982 the women's teams were fast and powerful enough to win bronze medals at the Bay State Games and the National Collegiate Women's Rowing Championships, and a silver at the National Sports Festival. They were also fast enough to run down a couple of ducks on the Charles River—justice, it is claimed, for what the ducks do to the docks.

Ducks are not the only obstacles the team has to overcome. Crew shells made in the early 1970s were designed for use by women weighing between 130 and 140 pounds.

The equipment has not kept up with the women using it. The coach had to rig splash-guards at the nationals to prevent the heavyweight shell, riding low in the water with four women weighing about 165 pounds each, from filling with water. One member of the varsity, in the Department of Ocean Engineering, spent the summer designing a better shell.

Winning has had an added meaning for Bradley. Jack Kelley, an official at the National Sports Festival, while hanging a medal around her neck, offered a special congratulation to the granddaughter of John Carlin—a former member of the U.S. Olympic Rowing Committee.—*Amy S. Gorin, '84, from* The Tech *(Reprinted by permission;* © 1983. The Tech).

dence at M.I.T., will present a new work for voice and computer in Kresge on March 3. Other composers chosen by Professor Barry L. Vercoe, director of the studio, and his colleagues include William Albright, professor of music composition at the University of Michigan; Martin Brody, assistant professor of music at Wellesley; and Peter Child, who teaches composition at Brandeis.

27 Fraternities Joined by One Sorority

"We've all hung out at fraternities, and we like the lifestyle that a fraternity affords—a warm, congenial atmosphere. So we asked ourselves, Why shouldn't we form a sorority?"

That's the explanation of Kathleen A, Harragan, '84, for the moves that are likely to bring Alpha Phi, the nation's oldest national social sorority, a chapter at M.I.T. within a year.

It started when 40 co-eds came together a year ago to form what they called "Club Amherst" for athletic and social activities. With official affiliation with Alpha Phi accomplished, the group's next step is to find an off-campus house in which the chapter can live.

Leading the ROTC Camp

ROTC cadets from the M.I.T. program were first among 15 units from New England last summer at the ROTC advanced camp at Fort Bragg, N.C. The winning 21 cadets earned points in all training subjects; most were attending summer camp between their junior and senior years to meet a requirement for commissioning.

Diana ben-Aaron

continued from page A2

Quality and safety are important to Gregor; he has posted signs throughout his labs detailing proper procedures and warning that "violators will be barred from the lab until suitably repentant." He stops at every piece of equipment as he passes through his domain, offering advice to the people using it in a broadly Boston-accented blend of Victorian diction, engineering jargon, and street slang: "What you have there is a thermometer, and that thermometer is of glass, and it contains mercury, and you must be very careful when inserting that thermometer into the mold not to exert a bending moment on it, or else it will break and the mercury will fly out and hit you right in the kisser."

Aiming for "Optically Flat"

The routine for each specimen begins with cutting it if necessary on a saw or cutting wheel to produce a flat surface. Gregor exhibits the latest in prison bars: the metal actually gets harder as one tries to file through it, but the saw, which operates by first heating the surface and then cutting through it "like butter," makes short work of the strongest grill. Cut specimens are usually embedded in acrylic or Bakelite, to make them easier to hold on the grinding and polishing equipment and the microscope. The tennis racket string amply demonstrates the need for such mounting—"I couldn't just hold that against the wheel, level," says Gregor. "*You* try it." Typically, the mounting material is poured around the sample in a cylindrical mold, with the sample face to be examined exposed on the lower flat face (bottom) of the cylinder. Both the specimen and the surrounding mount are then polished, but only the specimen is of interest.

Among his most interesting samples: a piece of the propeller from Jerome Wiesner's old boat.

Grinding and polishing are done holding the specimen manually against a series of rapidly spinning wheels covered with successively finer grades of sandpaper (for grinding) and cloth (for polishing). At each stage, the scratches produced by the wheel abrading the sample become finer, and the surface becomes flatter and smoother. Cloth rather than sandpaper is used in polishing, the final step, because anything rougher would scratch the sample. After polishing, the scratches are microscopically small and the surface is said to be "optically flat."

When the specimen has been thus prepared, it has a mirror-like gloss and reflects microscope light evenly enough to reveal what is in it. Gregor, or whoever is working on it, can then examine it, test it, and compare it with other samples, either "live" or by taking photographs of each through the microscope ("photomicrographs") and comparing those. Examination of a sample often includes "etching": soaking the surface in chemicals that eat away at different surface structures "preferentially," causing them to appear in different colors or sharper contrast under the microscope. Structures of interest include specific elements or compounds which are physically distinct from the whole ("phases"), porosity (or "holes" in the specimen), porosity (or "holes" in the specimen), cracks, and crystal grain boundaries. Hardness tests can also be done in Gregor's lab using a standard indenter which strikes the sample surface; the relative hardness can be calculated from the depth or length of the mark left by the indenter. Gregor can estimate the relative areas of phases or other structures on the sample surface and use them as a measure of the relative volumes in the bulk material. The conclusions drawn from all this depend on the assumption that the plane of polish is representative of the bulk material, an assumption that, according to Gregor, is usually valid and can be checked by preparing and comparing several specimens of the same material from the same source.

Arthur Gregor loves his work and is willing to talk about it almost indefinitely, frequently enriching his monologue with examples and demonstrations and ending each with the rationale for his vocation, as in the following snatch of conversation: "See this? It's the old lock from my door. They changed locks a few years back and I asked if I might have the old one to cut open. So I mounted it up and polished it up nice! . . . see the smooth brass microstructure in the photo, the absence of crystals? That's powder metallurgy—they just compacted the powder and heated it up and formed the lock. That's all I wanted to see. Just wanted to see what it was made out of."

Obituaries

R.B. Newman

Robert B. Newman, 1917-1983 Architectural Acoustics Expert

Robert V. Newman, M.Arch.'49, adjunct professor of environmental controls at M.I.T. who was a founding partner of Bolt, Beranek and Newman, Inc., Cambridge, died on October 2 of a massive heart attack. An internationally known acoustical consultant and lecturer, he was 66.

Professor Newman, born in China, graduated from the University of Texas with two degrees in physics before coming to M.I.T,., where he joined the staff immediately after completing his architectural degree, teaching in the field of acoustics. He became associate professor in 1956 and assumed the title of adjunct professor in 1976. He also taught in Harvard's Graduate School of Design.

Professor Newman held the Brown Medal of the Franklin Institute and in 1977 was awarded a Quarter Century Citation by the Building Research Advisory Board of the National Research Council.

Gordon Y Billard, 1900-1983

Gordon Y Billard, '24, financial consultant, engineer, and economist of New York City, died unexpectedly on September 18. He was 83.

Mr. Billard studied management at M.I.T. and was an officer of several investment banking firms prior to service in the U.S. Navy during World War II. He returned to these firms and to hold directorships in a number of companies after the war, retiring in 1976.

Billard founded the Gordon Y Billard Fund at M.I.T. in memory of his mother a number of years ago, and shortly before his death he made arrangements for the Gordon Y Billard Professorship in Management and Economics to be held by a faculty member studying national and international issues relating to economics, finance and politics."

M.I.T. will be residuary beneficiary of Mr. Billard's estate, and Glenn P. Strehle, '58, treasurer of the Institute, believes Billard will be the largest individual donor to the Sloan School since the original gifts by Alfred P. Sloan, '95.

Ralph H. Whittemore

Ralph H. Whittemore, instructor in mechanical engineering, died at his home in Bridgewater, Mass., after a lingering illness on August 23. He was 59. Mr. Whittemore shared the 1981 Murphy Award, and in the same year he won the Holt Award for outstanding service to the Department of Mechanical Engineering.

Deceased

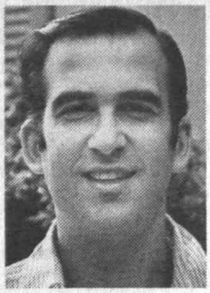
Mrs. Ferruccio Vitale, '03; 1978; 925 Park Ave., New York, N.Y.
William L. Spalding, '05; June 14, 1983; 520 Kenosha Ave., Norfolk, Va.
Francis H. Boynton, '15; 1980; 1428 S. Marengo Ave., Holt Bldg. 13, Alhambra, Calif.
Glover M. Birk, '17; 1981; 1542 Sunset Dr., New Albany, Ind.
Norris G. Abbott, Jr., '20; July 17, 1983; 1180 Narragansett Blvd., Apt. G-1, Cranston, R.I.
Frank E. Beatty, '22; 1982; 29051 Pacific Coast Hwy., Malibu, Calif.
Roland H. Becker, '22; May 13, 1983; 129 Bay Point Dr. NE, Saint Petersburg, Fla.
Edward L. Norton, '22; January 28, 1983; 17 Lorraine Pl., Summit, N.J.
Winchester G. Blake, '23; October 12, 1981; 513 Spring Valley Rd., Media, Penn.
Gordon Y Billard, '24; September 18, 1983; 860 United Nations Plaza, New York, N.Y.
Everett V. Martin, '24; September 23, 1983; 21800 Morley No. 907, Dearborn, Mich.
Ralph A. Reid, '24; September 7, 1983; 1044 Kanuga Rd., Hendersonville, N.C.
Ira D. Chambers, '25; January 26, 1983; 5539 No. Saguaro Rd., Scottsdale, Ariz.
Paul E. Hess, '25; September 28, 1983; 23 Watson Circle, Montgomery, Ala.
Walter E. Campbell, '26; October 24, 1983; RFD Tolman Pond, Marlborough, N.H.
Donald C. Hill, '26; September 26, 1983; 6100 Bivens Ct., Norfolk, Va.
Harry S. Falkoff, '27; 1982; 29 Whiting Farm Rd., Branford, Conn.
Frank G. Kear, "27; July 21, 1983; 501 Portola Rd. No. 8085, Menlo Park, Calif.
Malcolm Mitchell, '28; August 21, 1983; 944 Spannwood Dr., Indianapolis, Ind.
Joseph K. Roberts, '28; April 3, 1983; 35 Maysenger Rd., Mahwah, N.J.
Masaomi Yoshida, '29; June 19, 1975; c/o Toa Valve Co., Ltd., 1113 Toribayashi Mizudo, Amagasaki, Hyogoken, Japan.
Lawrence N. Gonzalez, '30; August 16, 1983; 7116 Exfair Rd., Bethesda, Md.
John W. Carleton, '31; 1980.
Alfred B. Berghell, '32; May 31, 1983; 454 Piney Way, Morro Bay, Calif.
Kenneth A. Cameron, '32; August 4, 1983; 159 Parkview Ave., Lowell, Mass.
Francis S. Chambers, Jr., '32; 1983; 309 Dickinson Ave., Swarthmore, Penn.
Bertram D. Kribben, '33; June 17, 1983; 526 Orchard Ln., Winnetka, Ill.
Robert M. Love, '33; October 9, 1983; Tyrone Farm, Tyrone Rd., Pomfret, Conn.
Bretton Perry, '33; September 5, 1983; Appletree Ln., Norwalk, Conn.
Horace Wayne Taul, '33; June 1983; 168 Milliken Creek Dr., Napa, Calif.
W. Harold Bagley, Jr., '35; August 20, 1983; 3032 Morningview Terr., Birmingham, Mich.
Daniel B.F. Clapp, '35; 1982; 109 Grove Way, Esher Surrey, England.
William B. Lauder, '35; March 3, 1983; Poetas 506, Leon GTO 37160, Mexico.
John A. Barclay, '36; May 28, 1983; 6814 Garth Rd. SE, Huntsville, Ala.
John L. Speirs, '36; October 12, 1983; PO Box S, Shoreham, L.I., N.Y.
Clark Goodman, '40; June 23, 1983; 95 Antigua Ct., Coronado, Calif.
Leo W. Rainard, '40; September 20, 1983; 107 Lighthouse Rd., Edgewood Hills, Wilmington, Del.
John C. Conroy, '44; 1981; 55 Yates St., St. Catharines, Ont., Canada.
John F. Bowen, '48; 1983; 4207 Aspen Ln., Somis, Calif.
Alfred B. Muller, '48; August 10, 1983; 195 Hemlock Ln., Kinnelon, N.J.
Robert A. Newman, '49; October 2, 1983; PO Box 349, Lincoln Center, Mass.
Charles W. Sherman, '49; June 1983, PO Box 592, Ligonier, Penn.
Maynard J. Lebowitz, '50; September 10, 1983; 4 Monadnock Rd., Chestnut Hill, Mass.
Jerome A. Lewis, '50; July 14, 1983; 935 Ridgedale Dr., Lawrenceville, Ga.
Matthew C.C. Chisholm, Jr., '51; 1982 2940 NE 188 St., Miami, Fla.
Arthur W. Carlson, '52, June 5, 1983; Harrison, Maine.
Herbert F. Head, '52; August 23, 1983; 1332 Don Kirk St., Los Altos, Calif.
George L. Roehr, '52; September 13, 1983; PO Box 134, Lincoln, Mass.
Joseph M. Van Horn, '53; September 18, 1983; 9 Blanchard Rd., Cambridge, Mass.
John S. MacNairn '54; June 13, 1983; 2472 Brenthaven Dr., Bloomfield Hills, Mich.
Robert Bowman, '55; August 9, 1983; 4030 Montwood Ln., Dallas, Tex.
Luther Edward Stone, Jr., '57; December 27, 1981; 1742 Hummingbird Ct., PO Box 92, Marco, Fla.
Marshall R. Jones, '63; June 1, 1983; 125 Lincoln Ave., Mineola, N.Y.

Not Deceased: Tillman

We are sorry for the error but happy to report that **James Tillman,** '58 (listed here in the August/September issue) is alive and well in Seattle, Wash.

Can 1984 Be As Good as 1983?

Puzzle Corner/Allan Gottlieb



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This being the first issue of another year, we again offer a "yearly problem" in which you are to express small integers in terms of the digits of the new year (1,9,8, and 4) and the arithmetic operators. The problem is formally stated in the "Problems" section, and the solution to the 1983 yearly problem is in the "Solutions" section.

Problems

Y1984 Form as many as possible of the integers from 1 to 100 using the digits 1,9,8, and 4 exactly once each and the operators +, -, × (multiplication), / (division), and exponentiation. We desire solutions containing the minimum number of operators; and, among solutions having a given number of operators, those using the digits in the order 1,9,8, and 4 are preferred. Parentheses may be used for grouping; they do not count as operators.

JAN 1 Doug Van Patter asks us a bridge problem based on the following hand that actually occurred in a tournament.

	♠ J 9 8 5 2 ♥ A ♦ — ♣ A K Q 10 9 6 4	
♠ A Q 3 ♥ K J 3 ♦ A J 10 8 6 ♣ J 2		♠ K 7 ♥ 9 6 5 4 2 ♦ K Q ♣ 5 3
	♠ 10 6 4 ♥ Q 10 8 7 ♦ 5 4 3 2 ♣ 8 7	

South is declarer at a contract of four spades; West leads the ♦A. Would you choose to be declarer or defender?

JAN 2 A *Technology Review* reporter took a poll among a number of readers and found that 91.3 percent enjoyed "Puzzle Corner," a value accurate to three digits. What is the minimum number of readers the reporter could have polled for this value to be so accurate?

JAN 3 Winthrop Leeds has a three-part problem about the design of the soccer ball in current use. The ball appears to be made from 32 pieces of leather, 12 black pieces in the shape of regular pentagons and 20 white pieces in the shape of regular hexagons. Instead of forming a polyhedron, air pressure pushes the sides out into a circumscribing sphere. How many vertices does the basic polyhedron have? Do all of these vertices lie on the circumscribing sphere? If the edge of each pentagon and each hexagon is exactly 2 inches in length, calculate the diameter of the circumscribing sphere.

JAN 4 We end the regular section with a problem Dan Dewey sent to the M.I.T. Physics Department student newsletter. On the planet Trayshowed in a distant galaxy, an earth scientist was asked to measure the black body temperature of the sun. Their day/night cycle was 36 hours, so the scientist was somewhat frazzled; however, he was spared a little work when he noticed that sunlight would enter his appartus for a full 6 minutes without having to move it. As predicted, the blackbody equivalent temperature was found to be 5500 Kelvin. What kind of clothing did our scientist wear? (French scholars: take a guess. Physicists: calculate the average surface temperature of Trayshowed!)

Speed Department

SD1 Phelps Meaker offers a sidewalk speeder: A straight sidewalk is to be constructed of pre-cast concrete slabs—alternate isosceles trapezoids and rhombuses. There are ten trapezoids and eleven rhombuses. Two right-angle triangles are provided to dress up the ends. The altitude and the two parallel sides of the trapezoids are in the ratio 2:3:4. The rhombuses are 34 inches on a side. What are the width and length of the walk (within 1/4 inch)?

SD2 A gem (ruby) from Art DeLagrange. Here's a quickie: The Rubik's

cube (3×3) has 26 sub-cubes, or "cubies," as the one in the center does not really exist. Each face has nine "facies," for 54 total. The six center facies do not move (only spin); the 48 remaining facies all have unique locations. They belong two to an "edge" cubie or three to a "corner" cubie. Do more belong to edge or corner cubies? Also, define the equivalent problem for the 4×4 cube and solve it.

Solutions

Y1983 Apparently 1983 *is* a very good year (remember, I write this in early October) since only two numbers cannot be formed as exemplified by Rik Anderson's solution:

1—1^{983}	51—1 × [3 × (9 + 8)]
2—38/19	52—1 + [3 × (9 + 8)]
3—18/(9 − 3)	53—91 − 38
4—9 + (8 − 13)	54—18(9/3)
5—3 + (18/9)	55—8(3 − 1) − 9
6—18 − (3 + 9)	56—8 × [9 (3 − 1)]
7—8 − 1^{93}	57—19 + 38
8—91 − 83	58—89 − 31
9—9 × 1^{83}	59—(8 × 9) − 13
10—9 + 1^{83}	60—[9 × (8 − 1)] − 3
11—1^{9} × (8 + 3)	61—[8 × (9 − 1)] − 3
12—93 − 81	62—
13—13 × (9 − 8)	63—189/3
14—19 − (8 − 3)	64—83 − 19
15—18 − (9/3)	65—8 + (3 × 19)
16—1 − [9 − (8 × 3)]	66—198/3
17—1^{3} × (9 + 8)	67—98 − 31
18—9 + 8 + 1^{3}	68—(1 + 3) × (9 + 8)
19—38 − 19	69—81 − (9 + 3)
20—1 × (9 + 8 + 3)	70—1 − [3 − (9 × 8)]
21—39 − 18	71—(9 × 8) − 1^{3}
22—[3 × (9 + 1)] − 8	72—1^{3} × (9 × 8)
23—(8 × 3) − 1^{9}	73—83 ÷ (1 + 9)
24—19 + (8 − 3)	74—1 × (83 − 9)
25—1 + [8 × (9/3)]	75—93 − 18
26—(9 × 3) − 1^{8}	76—89 − 13
27—81/(9/3)	77—[8 × (9 + 1)] − 3
28—38 − (1 + 9)	78—81 − 9/3
29—1 × (38 − 9)	79—
30—19 + 8 + 3	80—91 − (8 + 3)
31—1 × (39 − 8)	81—3 × (19 + 8)
32—1 + (39 − 8)	82—83 − 1^{9}
33—3 × (19 − 8)	83—83 × 1^{9}
34—1 + 9 + (8 × 3)	84—93 − (1 + 8)
35—1 × [8 + (3 × 9)]	85—98 − 13
36—9 + (81/3)	86—1 + (93 − 8)
37—38 − 1^{9}	87—1 − (3 − 89)
38—38 × 1^{9}	88—89 − 1^{3}
39—38 + 1^{9}	89—89 × 1^{3}
40—39 + 1^{8}	90—89 + 1^{3}
41—(8 × 9) − 31	91—9 + (83 − 1)
42—81 − 39	92—1 × (9 + 83)
43—19 + (8 × 3)	93—1 + (9 + 83)
44—8 + [9 × (3 + 1)]	94—98 − (3 + 1)
45—18 + (3 × 9)	95—19 × (8 − 3)
46—9 + (38 − 1)	96—1 + (98 − 3)
47—1 × (9 + 38)	97—98 − 1^{3}
48—1 + (9 + 38)	98—98 × 1^{3}
49—98/(3 − 1)	99—98 + 1^{3}
50—(1 + 9) × (8 − 3)	100—98 + (3 − 1)

Also solved by Ron Newman, A. Holt, Allen Tracht, Kenneth Fawcett, Bill Dawson, Maria Petrocchi, Jay Roth, Harvey Fletcher, George Aronson, John Fine, Rik Anderson, Hal Steiner, Avi Ornstein, Harry Garber, Allan Katzenstein, Phelps Meaker, Harry Zaremba, David Evans, Linda Furrow, Burt Grosselfinger, and Rudy John.

A/S 1 In the situation shown at the top of the next column, White is to play and draw.

A detailed solution from David Evans. White cannot hope to win unless Black blunders. The passed KRP cannot be queened, and there is not enough time to clear the QR file before Black breaks through in the center. 1. K-K4 stops Black's pawn temporarily, but meanwhile Black merely picks off the KRP, then swings around with his king and eventually forces his way through in the center. White must therefore play for stalemate at QR5, with his QRP's at R4 and R6, his BP permanently immobilized, his KRP captured, and a Black pawn

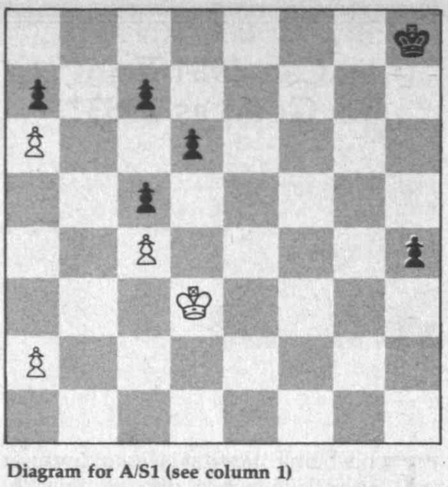


Diagram for A/S1 (see column 1)

at B3. The move P-B3 is natural for Black in his effort to clear the center, but he will avoid making it if he recognizes White's attempt to force a draw. Thus White loses if he merely pushes his KRP and heads for QR5: e.g., 1. P-R5, K-R2; 2. P-R6, K×P; 3. K-B3, K-N4; 4. K-N3, K-B5; 5. K-R4, K-K5; 6. K-R5, K-Q5; 7. P-R4 loses to 7. . . . P-Q4. If 8. P×P, P-B5; if 8. K-N5, P×P and in both cases Black queens first.

Therefore White must force Black to play P-B3. This is accomplished with:
1. K-K4
The threat is 2. K-Q5 followed by 3. K-B6. Black cannot ignore this threat: e.g. if 1. . . . K-R2; 2. K-Q5, K-R3; 3. K-B6, K-R4; 4. K×P(B7) wins since of 4. . . . K×P; 5. K×P followed by 6. K×P and White queens; or if 4. . . . P-Q4; 5. K×QP and Black's QBP falls quickly. Black's king cannot help since it must guard White's KRP: e.g., 1. . . . K-N2; 2. K-Q5, K-B3; 3. K-B6, K-K4 loses to 4. P-R5, for if now 4. . . . P-Q4; 5. P-R6 and Black must retreat to the corner, after which White mops up in the center as before.

Thus Black must prevent White's 2. K-Q5. The reply 1. . . . P-Q4 ch obviously loses quickly, so 1. . . . P-B3 is forced. Now White must force immobilization of his BP, since he cannot allow Black to force an exchange at White's Q5: e.g., 2. K-Q3, K-R2; 3. K-B3, K-R3, 4. K-N3, K-R4; 5. K-R4. K×P; 6. K-R5, K-N5; 7. P-R4 and Black still wins with 7. . . . P-Q4; 8. P×P, P×P and stalemate is broken. Then 9. K-N5 (forced), P-B5!; 10. K-N4 (forced—else 10. . . . P-B6 and queens), K-B5; 11. K-B3, K-K6 and Black queens. Thus White must force Black to play P-Q4 and P-Q5, after which White can reach his stalemate at QR5. This is accomplished by:
2. K-B5. . . .
If now 2. . . . K moves; 3. K-K6, K moves; 4. K×P and White wins, for Black cannot save the BP's and simultaneously stop the queening threat on the QB and KR files; or 3. . . . P-Q4; 4. P×P, P-B5 (not 4. . . . P×P: 5. K×P followed by 6. K×P and White wins); 5. P×P and White queens first, capturing at QB1 when Black queens. So, 2.. . . P-Q4 is forced. Now:
3. K-K5
If 3. . . . P×P, 4. K-K4 and Black cannot queen—e.g., 4. . . . P-B6; 5. K-Q3, P-B7; 6. K×P (or 5. . . . P-B5 ch; 6. K×P (B3)) and Black loses all his QBP's, enabling White to queen on one or the other of the rook files. If instead 3. . . . K moves; 4. P×P followed by 5. P×P as above and White wins. Therefore Black must play 3. . . . P-Q5, and White has achieved his objective. Black, of course, cannot advance his QP without his king's support, and this gives White the time he needs to reach stalemate: 4. K-K4, K-R2; 5. K-Q3, K-R3, 6. K-B2, K-R4; 7. N-N3, K×P; 8. K-R4; or 4. . . . K-N2; 5. K-Q3, K-B3; 6. K-B2, K-K4; 7. P-R5 and Black must return to the corner. In either case, White reaches QR4 before Black can advance QP; e.g., continuation of the former line of play gives: 8. . . . P-Q6; 9. K-R5, P-Q7; 10. P-R4 stalemate. The latter line would continue: 7. . . . K moves (not 7. . . . P-Q6 ch; 8.

K×P and White reaches QR5 and pulls up the QRP before Black can elminate the KRP and break the logjam on the QB file); 8. P-R6 and Black must retreat. Of course, if Black plays P-Q6 before White reaches QR4, White simply captures, then queens on either the QB or KR file.

Also solved by Robert Way, Matthew Fountain, Ronald Raines and the proposer, Bob Kimble.

A/S 2 A total of 14 coins are arranged in four horizontal rows with 2,3,4, and 5 coins, respectively:

● ●
● ● ●
● ● ● ●
● ● ● ● ●

Two opponents, "A" and "B," take turns picking up any one or more coins from any one horizontal row until one opponent wins by leaving the last coin for the other opponent to pick up. If "A" starts, there will be no way for "A" to win regardless of his first move, unless "B" fails to make the right moves thereafter. The problem is to identify how few and what configurations "B" can leave for "A" on "B"'s first move (after any starting move by "A") so that "B" can win, regardless of any subsequent move by "A."

Thomas Stowe correctly determined that there are four configurations "B" can leave for "A":
Piles containing 1, 2, and 3 coins.
Piles containing 1, 4, and 5 coins.
Piles containing 2, 2, 3, and 3 coins.
Piles containing 2, 2, 4, and 4 coins.

Henry Curtis analyzed the entire game:
A foolproof approach for B to win the "2-3-4-5 coin game" is to present player A with an "even configuration" on each play until near the end. To determine whether an "even configuration" exists, follow these two steps:
1. Express the number of coins in each row as a binary number. for the starting position, this would be:

Row number	*Number of coins: Decimal*	*Binary*
1	2	10
2	3	11
3	4	100
4	5	101

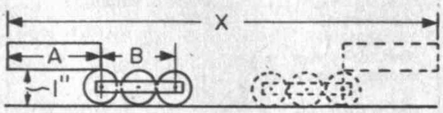
2. Count the number of non-zero digits in each column of the binary listing. If the number of non-zero digits in every column is even, then the array is "even." For the starting position, there are two non-zero digits in the units column, two in the 2's column, and two in the 4's column, making the starting array "even."

Note that a player confronted with an "even" configuration at the beginning of his turn will have to leave an "odd" configuration for his opponent, no matter what move he chooses to make. On the other hand, a player confronted with an "odd" configuration can leave an "even" or "odd" configuration for his opponent, depending on the move he chooses to make. To force player A to take the last coin, B should then take all of the coins in the row containing more than one coin, leaving A with an odd number of rows, each containing one coin. As an example, suppose A starts by taking one coin from the longest row, leaving rows of 2, 3, 4, and 4 coins. B can make this an "even" configuration by taking one coin from the second row, leaving rows of 2, 2, 4, and 4 coins. For a second example, assume A takes all coins from the longest row, leaving rows of 2, 3, and 4 coins. B can leave an "even" configuration by taking 3 coins from the third row, leaving rows of 2, 3, and 1 coins, and so on. One can see that B can be the master of the game—i.e., he may choose in advance to force A to take the last coin or to prevent A from getting the last coin. For the latter option, B simply presents an "even" configuration to A throughout the game. The method outlined here works not only for the "2-3-4-5 coin game" but also for an expanded game of *any* number of rows with *any* number of coins in each row. B can win all the time, provided he has an opportunity to present an "even" configuration

to A sometime during the course of the game.

Also solved by Robert Way, David Evans, Matthew Fountain, John Woolston, Harry Zaremba, Richard Hess, Winslow Hartford, Emmet Duffy and the proposer, Donald Richardson.

A/S 3 A member A moves on rollers, without slipping, from the solid-line position to that shown in dotted lines. What is the value of X in terms of the lengths A and B?



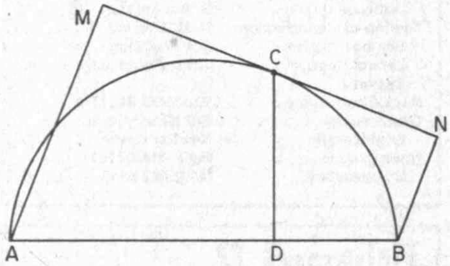
Karl Brendel shows us that the answer is
X = 3A + 2B

By inspection, if the rollers did not move relative to the floor, X would be equal to the distance moved by a point on the member, relative to the rollers, plus the length A. That distance is equal to A + B, so
X [Member Relative to Rollers] = 2A + B
However, we are given rollers move without slipping. Therefore, the rollers move, relative to the floor, the same distance moved by the point on the member, relative to the rollers: A + B
X [Rollers Relative to Floor] = A + B
The X we want is the summation:

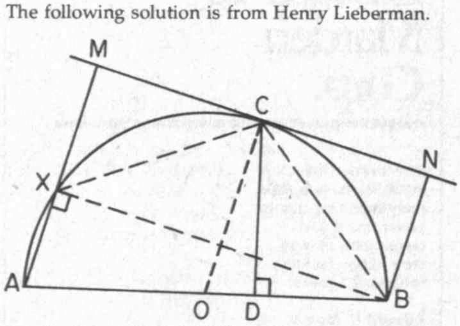
X [Member Relative to Floor]
= X [Member Relative to Roll] + [Roll Relative to Floor]
= 2A + B + A + B.
X = 3A + 2B

Also solved by David Evans, George Piotrowski, Thomas Stowe, Ronald Raines, Norman Wickstrand, John Woolston, Richard Hess, Harry Zaremba, Howard Wagner, Mary and Martin Lindenberg, James Abbot, Robert Way, Michael Neschleba, and Matthew Fountain.

A/S 4 In the drawing, C is a point on the semicircle with AB as diameter. MN is tangent to the semicircle at C. AM and BN are perpendicular to MN, and CD is perpendicular to AB. Show that CD = CM = CN and that CD^2 = (AM)(BN)



The following solution is from Henry Lieberman.



Let the intersection of AM and the semicircle be X and draw BX. Now angle BXA is a right angle since it is inscribed in a semicircle. Thus MNBX is a rectangle. Now let O be the center of the circle and draw CO. Since MN is tangent to the circle at C, CO is perpendicular to MN. Therefore, CO, MA, and NB are parallel. Since CO bisects AB, CO also bisects MN whereby CM = CN. Since CO is perpendicular to MN and MN is parallel to BX, CO is perpendicular to BX. Moreover, CO bisects BX since it bisects MN. So, CO is the perpendicular bisector of BX. Hence, chords CX and CB are equal. Therefore, arc CX = arc CB and so angle COD = angle XAB. So, triangle COD is similar to triangle XAB. The similarity of these two triangles implies

CD/XB = CO/AB = 1/2.

Therefore, CD = XB = MN = CM = CN, one of the desired results.

Observe that angles CAB and NCB are both measured by arc CB, and hence they are equal. Moreover, angle BCD = angle CAB since they are both compliments of the same angle. Hence, angle BCD = angle NCB and therefore triangle BCD = triangle BCN. Then DB = NB. Similarly, AD = AM. But, CD^2 = (AD)(DB) and therefore CD^2 = (AM)(BN), the second desired result.

Also solved by Steve Feldman, Avi Ornstein, Farrel Pownser, G. Yin, Winslow Hartford, Phelps Meaker, Karl Brendel, David Evans, George Piotrowski, Richard Hess, Harry Zaremba, Martin Lindenberg, James Abbot, Robert Way, Matthew Fountain, Raymond Gaillard, Apulia Servi, Norman Wickstrand, Emmet Duffy, Naomi Markovitz, and the proposer, Mary Lindenberg.

A/S 5 Which integers X have the property that 9X is the same as X with the digits in reverse order? There is one other integer multiplier (besides 9 and trivially 1) that reverses digits for an infinite number of integers. What is this multiplier and what are the multiplicands?

Robert Way found the solutions:
+11 × [integer part of (9.99 . . . × 10^a)]
where a is a positive number. He also determined that the other multiplier is 4 with mulitiplicands.
+100 × [integer part of 2.1999 . . . × 10^a)] + 78.
David Evans noted that the multiplicands for 4 are twice those for 9.

Also solved by Matthew Fountain, Richard Hess, Harry Zaremba, Winslow Hartford, Emmet Duffy, and the proposer, Susan Henrichs.

Better Late Than Never

FM 2 John Langhaar believes the area is 33.512.

FM 3 John Langhaar notes that in 1957 Sidney Clark submitted these equations to a brainteaser column edited by Mr. Langhaar. The solutions were

$x = \pm\ [(3^{1/3} + 3)^{1/2} \pm (3^{1/3} - 1)^{1/2}]$

$y = \pm\ [3^{1/3}(3^{1/3} + 3)^{1/2} \pm (3.9^{1/3} - 1)^{1/2}]$

where x and y must be taken of the same parity.

M/J 5 William Peirce found a simpler solution.

JUL 1 Mearle Smith, Alan Robok and Pi-Jan Sheu, John Woolston, and Emmet Duffy have responded.

JUL 3 John Woolston has responded.

JUL 4 John Woolston, Emmet Duffy, James Abbot, and Karl Brendel have responded.

JUL 5 Karl Brendel, Michael Jung, and Emmet Duffy have responded.

JUL SD 1 James Abbot tried the solution given, using two mirrors, and does not believe that it works.

A/S SD 2 George Holderness and Robert Way believe that there are better ways to play the hand.

Proposers' Solutions to Speed Problems

SD 1 W = 33″, L = 959.75″ (80 feet).

SD 2 For the 3×3, there are 8 corners with 3 facies and 12 edges with 2, for an equal number of 24. For the 4×4, things are a bit more complicated. There are 56 cubies, with 2×2 subset in the center nonexistent. Some are duplicates. All move. There are 96 facies; their locations are not necessarily unique. There are now 24 facies on center cubies, 48 facies on edges, and still 24 facies on corners.

Massachusetts Institute of Technology

Report of the President

For the Academic Year 1982-83

For MIT, the year just ended was one of remarkable vitality and considerable tension. It was a year of sustained excellence in our academic programs, a year of budgetary stringency, a year of taking risks and launching bold, new ventures, a year of facing up to hard choices regarding the use of limited institutional resources. And it was, as always, a year in which insistence on the highest quality in all that we do remained a touchstone.

The extraordinary calibre of our programs was recognized by national surveys and reflected in our unprecedented level of private support. MIT's tradition of seizing, indeed, creating, major new opportunities was evident in the launching of Project Athena—a far-reaching, institutional experiment to incorporate computers in new ways into our teaching and learning. A word about these highlights is in order.

During the past year the survey of graduate programs and faculties sponsored by the Conference Board of the Associated Research Councils provided an independent measure of the quality which has been a signature of the Institute since William Barton Rogers shaped his dream of a new kind of educational institution. In these reports MIT led the nation in the number of programs ranked first.* This is gratifying, but not surprising, given the exceptional quality of our graduate programs, of the associated research programs, and of the faculty who are responsible for these activities. Indeed, this insistence on quality infuses all the programs of the Institute—at the undergraduate level as well, where educational programs draw from and contribute to the corresponding research activities and courses of graduate instruction.

The Institute's standing in the world of higher education is reflected, as well, in the support which we have been able to generate from individuals and institutions throughout the country and throughout the world. This past year witnessed the highest level of private support in the Institute's history: over $50 million. Contributions from individuals, both alumni and other friends of the Institute, accounted for the greatest portion of this increase. The

*The study appraised programs in 32 fields, 17 of which exist at MIT. Thirteen of those programs were ranked in the top five and another three in the top ten. And nearly all of our other graduate programs, which were not included in this survey, are among the best in their fields.

BRADFORD HERZOG

increase of $9 million—or 22 percent—over the previous year is a tribute above all to our faculty, whose research and educational endeavors generate such confidence, enthusiasm, and high regard.

An example of the kind of vision and action so characteristic of our faculty and academic leaders is the inauguration this year of a massive educational experiment aimed at exploring how computers can accelerate and enhance the learning process. Started with resources provided by the Digital Equipment Corporation and IBM, the project is based on the premise that the next generation of personal computers represents a revolutionary new medium for learning.

This project, named Athena, after the Greek goddess of wisdom, calls for the integration of computers into educational programs throughout the university in ways that will help our students to learn more creatively and fully in a wide range of disciplines. Athena holds the promise of profoundly enhancing and extending the many ways in which we see and know the world around us.

Supporting the experiment will be thousands of personal computers and terminals, reinforced by mainframe computers, storage devices, and printers—all integrated into a single system. In addition, both IBM and DEC will have at least five representatives stationed at MIT to help develop the necessary computer networks for this project and to work with students and faculty in blending computers into the educational process. We are seeking

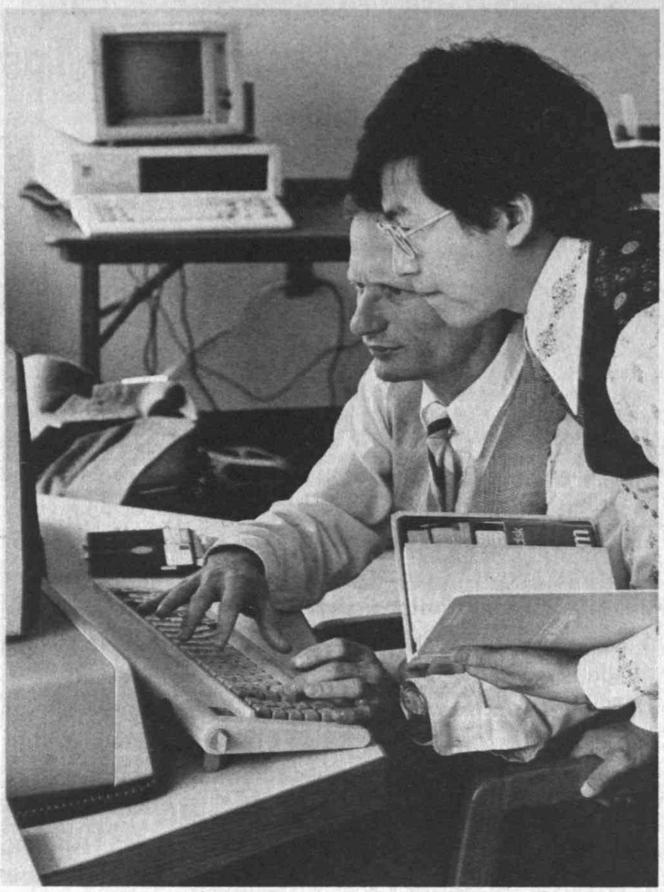
additional, major private funds for support of Athena—funds which will be used to fuel the faculty effort required to put these resources to full use in our educational programs.

The ultimate aims of this joint venture are to find out exactly how these powerful tools can aid students in visualizing difficult concepts, breathe new life into laboratory experiments, help develop the skills, knowledge, and insights needed for design problems, and even help cultivate that elusive talent we call intuition. This work has the potential for helping universities educate students for many disciplines—engineering, science, architecture, humanities, social sciences, and management—people who are better prepared to meet the needs of business, industry, and our whole society.

* * *

These signs of MIT's vitality and stature spring from the remarkable relationship between the institution and the individuals who are MIT. In some ways, the Institute is simply an idea—one which has drawn together and sparked the imagination of countless faculty, students, and staff since its founding. The **idea** of MIT, which began with William Barton Rogers's original goals, has evolved in response to the changing patterns of knowledge and the changing needs of society, but there are constants in that idea which stand the test of time. Three years ago, at the start of my presidency, I discussed those qualities which we must preserve, even as we transform programs to meet the needs of the future: an unswerving commitment to the quality and vigor of our core activities in engineering and science . . . the preservation and building of strong programs in the humanities, the arts, and the social sciences . . . the education of our students for civilized leadership as professionals and as citizens of the world . . . the intertwining of teaching and research as complementary and mutually reinforcing activities, a partnership that distinguishes MIT in the academic world. Looking to the years ahead, I spoke of the common goal which should inform all of our efforts: the development and sustenance at MIT of a more humane and complete intellectual mission, academic program, and sense of community.

We are now deeply involved in Institute-wide planning—a process which we see as a continuing feature of our academic programs and administrative services. I believe that conceptual, substantive, and integrative planning is the cornerstone of good leadership in higher education. While our current financial circumstances and the existence of deficits are a principal motivation for the investment of much energy and time in planning, these efforts have a purpose which transcends our present problems with the operating budget. Planning as an integral, ongoing part of our responsibilities is essential to preserving the vitality and excellence of the Institute in the future.



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Planning is in no way intended to determine rigidly the future direction of the Institute and its programs. There will always be year-to-year modifications and room for unexpected exciting new initiatives. The history of MIT is powerful testimony that no planning process should, let alone could, stifle the originality and creativity of this community.

Rather, we see the planning process as a guide or framework in which we can develop ideas and make choices about our programs. And we must choose. We simply do not have the resources to do everything that we **could** do. We must, as part of our regular planning, assess the value and priority of existing programs as well as possible new initiatives.

To be effective, planning requires a shared sense of the Institute's fundamental purpose. Our mission can be stated simply: To provide the highest quality programs in education and research, with a strong commitment to public service and to diversity of backgrounds, interests, and points of view among the faculty, students, and staff.

When informed by the special qualities of this place, the mission becomes a set of expectations that defines MIT.

The single most important part of our mission and the strongest bond holding us together is the undergraduate program. The academic goals served by the undergraduate program include, in variable measure, helping students to become qualified professionals; preparing them for entrance to graduate or professional school; and providing them with a broad cultural background in technology, the

natural and social sciences, and the humanities. The degree of emphasis on each of these goals varies among different departments and from one student to another. We believe that this freedom and diversity are healthy and should be preserved, within the context of our goal that all MIT graduates achieve a serious understanding of science, on the one hand, and of the humanities and social sciences, on the other.

Although we value the historic emphasis of MIT on science and technology, we wish to encourage the diversity of academic opportunities and interests among our students and faculty. We believe that this makes for a significantly richer educational experience and more successfully attracts the best students, including, but by no means limited to, those whose main focus will be on science and technology. Indeed, significant contributions to science and technology will come more often from men and women who are broadly cultured than from those who are narrowly specialized.

Our goal of ensuring a diversity of interests and points of view in our community depends, as well, on the presence of men and women from different backgrounds and cultures at MIT. We have done very well in building an international community here, but we have not yet achieved this goal when it comes to minorities and women. This problem is especially acute in the case of the small number of blacks and other minorities on our faculty. We are committed to change that situation and will continue to make special efforts to help that happen.

At the graduate level, our future is determined largely by the research interests of our faculty, which provide the basis, both in terms of intellectual structure and experience, for graduate education. Indeed, the research interests of our faculty provide the grounding for almost all that we do here. These interests change with time, as the disciplines evolve and as different, societal needs emerge. These changes are not simply responses to outside circumstances, however. Our faculty are leaders, and their research and scholarship lead to many of the changing patterns of knowledge, new understanding, and emergent questions that define the research environment. It is clear that our research will stay at the cutting edge and that our graduate programs will do the same.

As an outstanding educational institution and as a great research center, MIT is a national and a world resource, one which should be contributing, by its research and teaching, to the solution of the overriding social problems of our time. These problems include the danger of war, particularly nuclear war; the protection of our environment; the depletion of resources, especially energy; the need to open the opportunities and benefits of this society to all of our citizens; and the need to improve productivity and alleviate poverty in our country as well as in the rest of the world.

These expectations of MIT constitute a very demanding mission. The success of this mission is forged by the people of MIT — the faculty, students, and staff who, through their commitment to excellence, make the difference, each day, each week, each year. MIT has an obligation to its members to provide the kind of living, learning, and working environment conducive to their best and most creative endeavors. As we plan for the future, we must pay special attention to those issues affecting the quality of life of the people responsible for the success of MIT.

In this report I will discuss several issues which bear directly on the quality of life at the Institute and which require continuing attention if we are to attract and sustain the calibre of faculty, students, and staff who have been responsible for the quality of MIT.

* * *

The faculty of MIT, indeed of any of the principal research universities, bear a resemblance to the Roman god, Janus, with his two faces, one looking inward to the house and the other gazing outward toward the world beyond. Members of the faculty are responsible, together and individually, for the educational programs of the Institute — those in departments, as well as the core subjects and requirements which constitute the basis of an MIT education for all undergraduate students. In these respects, the faculty establish the expectations and the standards as well as the intellectual content of our educational programs. At the same time, our faculty engage in and have an uncommon influence on developments in the world of ideas.

These dual, synergistic roles on the part of the faculty are a principal source of MIT's distinction and strength. While Janus brought two countenances to bear on his task, however, the MIT faculty member must make do with one. Most faculty would probably still agree that being a professor is the best job, but there are strains and pressures that are seriously eroding the quality of academic life and that may discourage the very best young people from selecting academic careers altogether.

One such strain grows out of the imperative of maintaining, year after year, a reasonably stable base of financial support for research efforts. This means that faculty members are responsible for raising not only a portion of their own academic-year salaries but also support for undergraduate and graduate students, postdoctoral students and fellows, research staff members and technicians as well. During the past year the average amount of research support raised by each faculty member in fields where external support is provided was about $300,000.

The task of raising such funds is formidable and demanding. It requires continuous attention to the development of new supportable ideas, sensitivity to the shifting interests of research sponsors and cultivation of those interests, and a great investment of time in the preparation of proposals, progress reports, and other communications which nurture the relationship between sponsor and principal investigator.

It is even more difficult when the federal government, the principal patron of basic research, falters with respect to the general level of such support, or shifts patterns of support abruptly and in ways which take no account of the time constants of universities, or adopts formalities which may serve bureaucratic ends but which needlessly complicate the task of the investigator.

Under these circumstances, it takes an extraordinary amount of time and energy for a faculty member to fund his or her research program. This is a source of unrelenting pressure, particularly for junior members of the faculty who must establish their reputation as independent researchers, and it intrudes seriously on time for reflection and contemplation, for discussion of ideas and problems with one's colleagues, and for exploration of uncharted territories. The pressures to raise money and develop a fundable research program are placing real constraints on the ideas and research directions a faculty member might pursue.

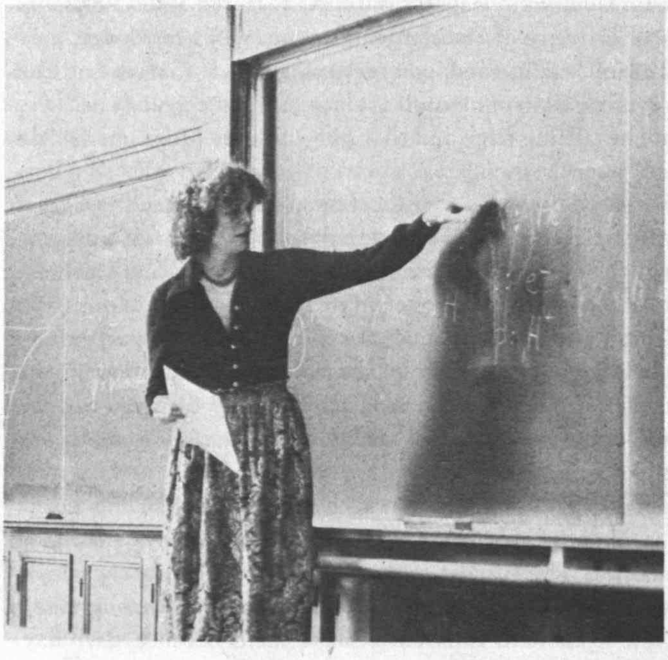
We need to support faculty members and their research in a way which enables and enhances their best efforts. This suggests renewed efforts to endow professorships and to increase our endowment in general, in order to bring into balance our faculty needs and our financial resources. Such an expansion would make it possible to relieve some of the pressure on faculty members to raise their own academic-year salary. It would also reduce the cost of research at MIT.

We should also continue to explore the opportunities for additional forms of research support, perhaps through closer cooperation with industry. At nearly $20 million, MIT already has one of the highest levels of industrially sponsored university research in the country, a record which speaks well of the enterprise of our faculty. There are questions as to whether the past strong growth in such support will continue, however, although certain fields (such as computation, biotechnology, materials, and microelectronics) seem promising. We should explore the opportunities here, paying special attention to the many questions which accompany industrial sponsorship of research—questions having to do with the character of research, the time scale on which it is done, the selection of research problems, and possible effects on the openness of the research enterprise.

And we must continue to work at containing the costs of research if we are to compete effectively for adequate support for our research programs. This means, in part, finding ways to reduce and stabilize the indirect cost and benefit burdens which add to the expense of research. This "overhead" is necessary to the performance of research, reflecting the real costs associated with space, libraries, departmental, interdepartmental and general administration, as well as the costs of the benefits which go with employment at MIT. For the past two years our budget reduction efforts have focused primarily on overhead costs and have been successful in reducing them by some 10 percent.

This has been a painful process, requiring the termination of programs and the elimination of jobs, and has contributed to tensions felt throughout the Institute this year. The reductions in support services which have been made or identified to date amount to $9 million and will prevent the overhead rate from increasing by about four percentage points. The cost-cutting measures were also instrumental in reducing this year's anticipated deficit to $3 million, and in reversing the trend toward growing deficits in the future. This year an effort was made to identify all reductions to be taken in the administrative areas over the next two years, in order to lower anxiety over possible but unknown future cuts. We will continue to work with those administrative areas which have not yet met their goals for reducing expenses, and our planning efforts will continue to seek creative ways to provide support services without increasing the overhead on educational and research activities.

All too often, the demands of maintaining a research program come into conflict as well with the intellectual energy and time required for teaching, advising, and counseling students. These conflicts are particularly severe in several departments in the School of Engineering where undergraduate enrollments have burgeoned during the past decade. The number of students majoring in the Departments of Mechanical Engineering, Chemical Engineering, and Electrical Engineering and Computer Science is particularly high. The latter department has seen undergraduate enrollments double in fewer than 10 years, and that single department now enrolls one out of every three undergraduates who have declared a major field of study. Counting both graduates and undergraduates, there are now more than 16 students per faculty member in that department (twice the Institute average), and each faculty member is supervising, on the average, eight thesis projects at any given time.


SCOTT GLOBUS

These enrollment patterns may or may not represent a sea change in student interests — many faculty believe they do — but at any rate, the teaching pressures on the Department of Electrical Engineering and Computer Science are already well beyond reason. We simply must find ways to limit this dramatic shift toward one department — not only to alleviate the strain on the faculty but also to ensure an essential diversity of intellectual interests and opportunities among our students.

Another factor affecting the quality of life for faculty at the Institute is the extraordinary competition for the recognition and stability which comes with promotion to tenure. There has always been a lively and stressful competition for tenured positions, even in the best of times. At the present time, however, with almost 70 percent of our faculty holding tenure, the competition for tenure and the associated pressures have been amplified. Not only are there budget constraints limiting the size of the faculty, but the age of the tenured faculty suggests that there will be only a modest number of retirements between now and the end of this decade.

These pressures, both real and magnified by the times and the grapevine, often cause an untenured faculty member to direct her or his energy almost entirely to research, where accomplishments can be assessed on the basis of "hard" data, and to assigned teaching. Often, little time or energy is left for the larger life of the institution, to say nothing of the family or the broader intellectual community.

We must find ways for the Institute to provide greater support for the junior members of our faculty. For example, we need to find ways to increase junior faculty salaries, and we should try to provide full salary support for an individual's initial appointment on the faculty. And we should seek additional funding for start-up research activities. We presently use both the Alfred P. Sloan Basic Research Fund and the Godfrey L. Cabot Solar Energy Fund in part for these purposes, when the nature of the work and the funds available permit. These endowed research funds are exceptionally valuable resources for MIT, and we should seek similar funding which could be employed to support research in other fields at the Institute.

It is important, too, that junior colleagues be given career guidance and advice by senior members of the faculty. Occasionally, the untenured faculty member feels isolated from senior colleagues, not having an established and effective relationship with a mentor. Such relationships are particularly important for women and for minority faculty who are often in the position of breaking new ground in their developing careers. It should go without saying, however, that **all** new members of this community need and can benefit greatly from relationships with senior colleagues who can provide the support, guidance, and constructive criticism necessary for professional development.

IVAN MASSAR, BLACK STAR

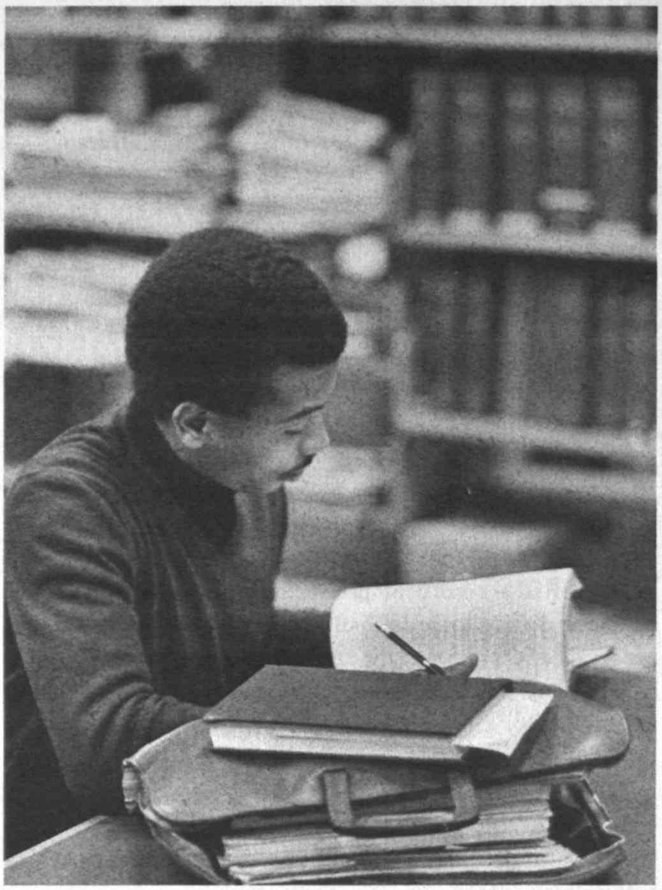
MIT has a record of producing great ideas and great people. If we are to be an institution for the future, we must preserve and enhance the quality of MIT as a congenial, stimulating, supportive setting for our faculty. For our junior faculty colleagues in particular, we must take care that career pressures do not stifle them or drive them away.

This report deals largely with issues affecting the faculty, but the quality of this institution depends on the students and staff as well. We are a community — a community made up of energetic, intelligent, feisty, imaginative, and individualistic people, to be sure. But as I look at the faculty, undergraduates, graduate students, research staff, academic, administrative, and support staff, working together to create the best possible educational and research programs, I think we have a very special place here. We each bring distinctive talents to this place, and the quality of our living, learning, and working conditions profoundly affects the quality of our contributions.

* * *

For students at MIT, the quality of their education is influenced not only by the faculty and the curriculum but by the range of their own interests and backgrounds — by what they bring and by who they are. While students have been attracted to the Institute in large part for scientific and engineering studies, these young women and men have enriched MIT and each other by the diversity of their intellectual and social interests, racial and cultural heritages, learning styles, and economic backgrounds. As we order our priorities for the future, the preservation and enhancement of this diversity must remain high on the list.

A major influence on the matter of who chooses to attend MIT (and whether they do, and why) is the cost of education at the Institute. Our success in enrolling students with a variety of interests and backgrounds depends in large measure on the existence — and visibility — of adequate financial-aid programs for our students.



BRADFORD HERZOG

Currently, more than half of our undergraduates come from the top 25 percent of the national income distribution, while fewer than one-tenth come from the lowest quartile. Over half of all undergraduates here qualify for financial assistance from the Institute and receive help in the form of subsidized loans, term-time jobs, and grants or scholarships.

During the past year needy undergraduates each received an average of nearly $9,000 in financial assistance, about half of which was in the form of a scholarship or grant. The Institute's total budget for grants to undergraduates last year was more than $12 million, $8 million of which came from MIT sources. Given the increasing need for financial aid, the Institute's scholarship endowment is no longer sufficient to meet those needs, and last year alone we spent $4 million in unrestricted funds to cover that need. The Institute's finances are stretched by these commitments to meet our financial aid policy. We have a pressing need to increase dramatically our endowment for financial aid: even a doubling of this endowment would not completely resolve this problem.

The Institute is not the only one to be stretched, however. Grants are awarded only after students and their parents contribute their "fair share." The average parental contribution last year was nearly $4,000; needy students contributed some $1,400 in summer earnings and assets; and met a "self-help" obligation of $4,000 through a combination of term-time work and loans.

Now I am talking about averages here; some families incur higher financial obligations, some lower. But it is clear that the costs — in terms of finances, time, and energy — are high, and we are concerned increasingly that these financial pressures influence students' choice of fields, academic performance, and opportunities to do anything besides work and study. That is a concern for the students who **are** here. Beyond that, we are asking ourselves whether the costs of attending MIT are so high, or are **seen** as so high, that they discourage other students from even applying.

At the graduate level we have similar concerns. While many graduate students in science and engineering are supported as research or teaching assistants, many in architecture, planning, the social sciences, and management are dependent solely upon personal resources, very scarce term-time jobs, and the Guaranteed Student Loan Program. As with the undergraduates, I am concerned about the effects of these financial circumstances on students' decisions whether or not to attend MIT and on the educational well-being of those who come: students who are preoccupied with financial issues are simply not able to bring their full energies to bear on their academic programs.

As these observations suggest, the cost of an MIT education and our financial aid resources are problematic for the university and the student alike. Last fall I appointed a task force to review our present financial-aid policy — beginning with undergraduate financial aid. That task force, chaired by Associate Provost Frank Perkins, was charged with evaluating the consequences and the costs of our present policy, to develop alternatives for consideration, and to make recommendations on future policy. We expect a report from that task force during the fall term.

The concerns for ensuring continued access to MIT by students from varied economic circumstances is but one issue relating to our goal of educating students with a broad range of perspectives, interests, and backgrounds. Beyond access, financial considerations seem to influence students' choice of fields and future career once they are here and, I fear, seem to reinforce a trend toward professionalism in undergraduate education.

I referred earlier to the problems created for the faculty by the dramatic increase in engineering enrollments — particularly in Electrical Engineering and Computer Science. This increase, certainly in part evidence of students' greater concern with the economic consequences of their academic decisions, also affects the quality of undergraduate education at MIT. The concern for getting on with one's professional education is reflected not only in choice of field but in a growing tendency to specialize as early as possible. Such decisions frequently limit the opportunities for a more general, exploratory, and varied educational experience which is especially important at the undergraduate level.

Our undergraduates should be encouraged — and should have the opportunity — to experience a variety of ways of seeing and knowing, of thinking about and grappling with the important questions of our time. It is true that scientific education and progress demand specialization, but we must guard against the companion

pressures toward isolation and narrowed vision. We have a responsibility to elucidate not only the powers but the limitations inherent in different disciplines and to explore the ways in which they inform each other.

The success of such goals depends on our being able to attract students with serious intellectual interests in a variety of fields and on our striking an appropriate balance between general and preprofessional educational goals.

We must, I believe, step up our efforts to present MIT as the university that it is in order to draw students whose serious engagement in a broader spectrum of fields helps to create a richer and more varied academic culture. Another way to do this might be to embark on a more ambitious program of transfer student admissions, with that specific goal in mind. Given the extraordinary enrollments in Electrical Engineering and Computer Science, we must find ways to generate student interest in other fields. I hope we can do so in a way which maintains our tradition of admitting students to the Institute rather than to specific schools or departments, but it may not be possible to preserve this freedom if enrollment pressures in engineering do not abate.

While the faculty share certain ideas about the foundation of an MIT education, the questions about balance between general and specialized education are by no means settled. Are the General Institute Requirements, which form the introduction to an MIT education for all undergraduates and which were last revised nearly 20 years ago, appropriate to the 1980s? Do departmental programs reflect a reasonable balance between general and preprofessional educational goals?

These are fundamental questions having to do with how students can best benefit from—and contribute to—the quality of MIT and the education we offer. The Committee on Educational Policy has been working steadily on the improvement of undergraduate education here. In remarks to the Corporation last spring, the outgoing Chairman of the Faculty, Professor Felix Villars, noted that while the faculty as a whole has not called for a reexamination of our educational premises and practices, he has heard a great deal of individual comment about these questions. He suggested that the time has come for a broad discussion among the faculty on issues of educational policy—a discussion which would generate a wide range of views and ideas which could lead to a shared understanding and set of recommendations concerning our educational goals. I welcome such an initiative and am pleased that Professor Villars's successor as Faculty Chairman, Professor Arthur Smith, is enthusiastic about engaging the faculty in consideration of these and other issues basic to the mission of MIT.

* * *

As we consider our future, I am reminded over and over that our teaching, research, and learning are not only enhanced but often made possible by all those who work to support our academic program. As I noted earlier, our planning and embarking on new ventures this year was accompanied by stringent cost-cutting measures, particularly on the administrative side of the house.

Planning for the development of the Institute, especially when undertaken in a climate of financial stringency, creates uncertainty and significant strain for all who work here. These uncertainties and strains are particularly acute for members of the administrative and support staff, who have borne most of the consequences, direct and indirect, of the staff reductions which have come about.

At the same time, the staff have shown an extraordinary willingness to lend their insights and experience to the planning activities—and to shoulder the consequences of organizational consolidation and change.

Throughout the Institute, staff members have stretched to provide high-quality service with lower budgets and reduced support, coming up with creative suggestions and cost-saving ideas. While the cost of the overhead—the administrative services in support of the academic program—has been the target for most reduction, the people in the administrative areas have become part of the solution rather than the problem. With a characteristic sense of dedication, often a sense of humor, and a "can-do" attitude, the staff has carried on under far-from-usual circumstances—and has gone the extra mile, time and again.

This is not to say that there have been no effects on the morale of the staff. The very closeness and collegiality in the MIT community—which are the sources of such goodwill in hard times—make staff reductions all the more visible and painful. And those who may be confident about their future employment may still wonder whether there will be opportunities for increased job satisfaction and professional development.

In any time—but particularly in these times—we must pay attention to the quality of MIT as a place to work. This means bringing staff into decisions affecting their jobs. It means greater willingness among departments to cooperate on Institute-wide projects—not only as a way of meeting new challenges with fewer resources but as a way of expanding professional experience and opportunity. And it calls for particular recognition on the part of senior officers and others of jobs well done.

I believe we have the spirit and the will to keep MIT an exciting and rewarding place to work. I know of no other university which enjoys such strong support and participation in its mission by all who work here. We must do all we can to keep that good fortune with us.

* * *

This place demands much. Some say too much. The demands on students, faculty, and staff **are** extraordinary—and so are their achievements. We must take care that pride in our success is not joined to pride in our ability to survive

CALVIN CAMPBELL

this place, however. As we plan for our future, we must remember that the quality of this university derives from the quality of the individuals here. The ways in which we support them, the kind of environment we provide for those who study and work here are fundamental to the attainment of the best and most creative endeavors. The creation of a more complete intellectual mission, educational program, and sense of community: the idea of MIT and the success of MIT demand no less.

Paul E. Gray
September 1983

In Special Recognition

Every year there are occasions which remind us of the unique manner in which individuals help to mold the character of the Institute. This past year several key leadership roles at the Institute changed, and those transitions were occasion for special recognition. In 1982 Howard W. Johnson announced his intention to retire from the Chairmanship of the Corporation at the end of the 1982-83 academic year. During his 28 years of service to the Institute, Howard Johnson has been a staunch defender of the university, a champion of the rights of all who study and work here, and a statesman and spokesman for higher education.

As President and as Chairman of the Corporation, Howard Johnson is living testimony to his own proposal that institutions, like individuals, need care if we are to have a society worth living in. His vitality and disciplined energy, his wise judgment, his warm relations with his colleagues, his humility, and his remarkable sense of humor have enriched all. I am delighted that he will continue as Life Member of the Corporation, Honorary Chairman, and as Special Faculty Professor.

At its December meeting the Corporation unanimously elected David S. Saxon as Chairman of the Corporation, effective July 1, 1983. Dr. Saxon received his bachelor's degree from MIT in 1941 and in 1944 his Ph.D. in physics, also from MIT. In 1947 Dr. Saxon went to the University of California, where he served in a variety of positions for 36 years, serving as President and Chief Executive Officer from 1975 until June 1983.

Dr. Saxon comes to MIT with a lifetime of experiences at another great university. The perspectives which he brings from the University of California will be of enormous value to MIT and I am elated that he has agreed to join his alma mater, taking on the leadership of the MIT trustees and bringing his energies to bear on fundraising for our academic programs.

In the spring Kenneth R. Wadleigh, Vice President and Dean of the Graduate School, announced his decision to return to the Mechanical Engineering faculty following a year's leave of absence. Professor Wadleigh had a major role in the building of many vital MIT programs including the residence system for undergraduates; the organization and growth of student services throughout the 1960s; the development of graduate school policies, recruitment of minorities, and support for all graduate students, and the establishment of high quality health services for the entire MIT community. Ken Wadleigh's limitless energy and dedication to MIT, his extraordinary contributions, and his no-nonsense, efficient style have won him a special place in the history of this institution.

The special character of MIT is also seen each year in the achievements and honors of its faculty. While it is not possible to take note of every such distinction, there are some highlights which deserve mention.

In the spring, five MIT faculty members were elected to membership in the National Academy of Engineering. The faculty members are: Thomas B. Drew, Professor Emeritus in the Department of Chemical Engineering; Harry C. Gatos, who holds a joint appointment as Professor in the Department of Materials Science and Engineering and the Department of Electrical Engineering and Computer Science; Charles C. Ladd, Professor in the Department of Civil Engineering; Alan L. McWhorter, Professor in the Department of Electrical Engineering and Computer Science and also Head of the Solid State Division at Lincoln Laboratory; and Kenneth A. Smith, Associate Provost and Vice President for Research and Professor in the Department of Chemical Engineering. This election brings to 71 the number of MIT faculty who are members of the Academy.

Professor George B. Benedek of the Department of Physics was elected a member of the national Institute of Medicine.

This past year the National Academy of Sciences elected four of MIT's faculty as members of the Academy. They are: Alar Toomre, Professor of Mathematics; Mary Lou Pardue, Professor of Biology; Phillip A. Sharp, Professor of Biology, and Stanley R. Hart, Professor of Geology and Geochemistry.

Later in the spring the American Academy of Arts and Sciences elected the following six faculty members: Victor W. Guillemin, Professor in the Department of Mathematics; Harold M. Stark, Professor in the Department of Mathematics; Robert W. Balluffi, Professor in the Department of Materials Science and Engineering; Erich P. Ippen, Professor in the Department of Electrical Engineering and Computer Science; Jack L. Kerrebrock, Professor in the Department of Aeronautics and Astronautics, and Phillip A. Sharp, Professor in the Department of Biology.

Four members of the MIT community were elected fellows of the American Association for the Advancement of Science: Loren R. Graham, Professor in the Program in Science, Technology, and Society; Edward N. Lorenz, Professor in the Department of Earth, Atmospheric, and Planetary Sciences; Kosta M. Tsipis, Principal Research Scientist in the Department of Physics, and Sheila E. Widnall, Professor in the Department of Aeronautics and Astronautics.

Earlier in the year Norman C. Rasmussen, Professor in Nuclear Engineering, was nominated by President Reagan to serve a six-year term on the National Science Board. The National Science Board is the policymaking body for the National Science Foundation and includes 24 members selected by the President and the Director of the Foundation.

Last fall Institute Professor Walter A. Rosenblith was honored by Israel's Weizmann Institute of Science when he received the first Dewey D. Stone-Harry Levine Arts and Sciences Award. Professor Rosenblith has been a governor of the Weizmann Institute since 1973 and earlier was Weizmann Lecturer there.

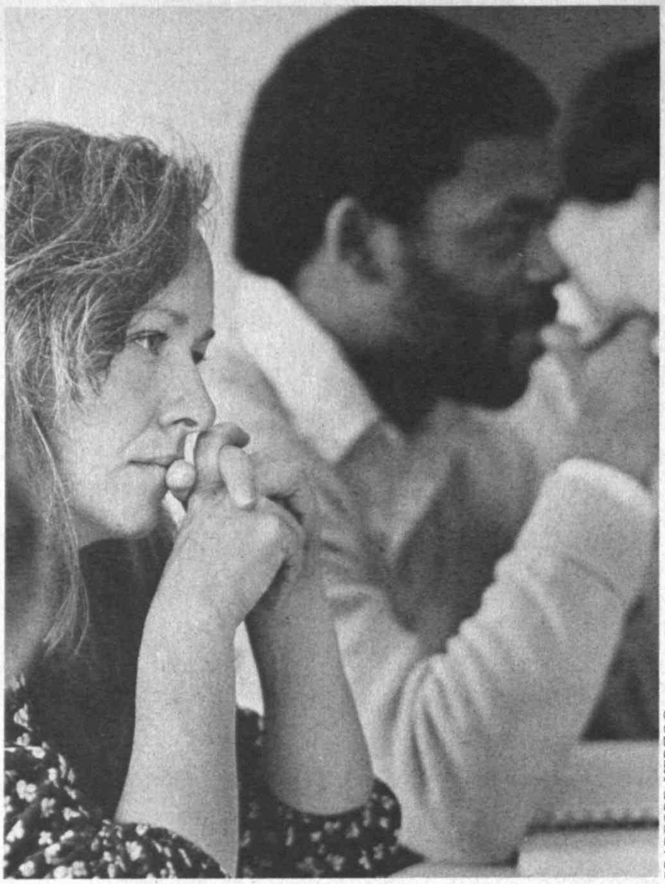
In the late spring Jerome B. Wiesner, Institute Professor and President Emeritus, was awarded the First Class of the Order of the Sacred Treasure by the Government of Japan. He was selected to receive this award for his support of the growth of numerous MIT programs strengthening ties with Japan and contributing to the exchange of science and technology between the United States and Japan.

Professor Charles F. Sabel in the Program in Science, Technology, and Society was the recipient of a MacArthur Prize Fellows award given by the John D. and Catherine MacArthur Foundation. The prize was established to recognize and give exceptionally talented individuals the financial freedom to pursue their field of interest.

Within the Institute, Herman Feshbach, Cecil and Ida Green Professor of Physics, was appointed Institute Professor upon recommendation of a special faculty committee. This honor is bestowed on a faculty colleague who has achieved special distinction through a combination of leadership, achievement, and service in the scholarly, educational, and general intellectual life of the Institute or wider academic community.

Robert W. Mann was selected by colleagues to be the 1983-84 recipient of the James R. Killian, Jr., Faculty

IVAN MASSAR, BLACK STAR


BRADFORD HERZOG

Achievement Award. The Award recognizes extraordinary professional accomplishments and service to the Institute. The Award citation reads, in part, "It is a subtle synthesis that leads to real, working, and needed engineering devices, a synthesis that is based on analysis and understanding, but that goes beyond to judgment, to a sense of values, and to sustained leadership. Those are what Robert Mann has brought to his work at MIT, work known worldwide for two decades, and recognized by consultancies, editorships, chairmanships, and awards too numerous to list."

In late May, Associate Professors Isabelle de Courtivron, a scholar in French language and literature, and Warren P. Seering, a mechanical engineer specializing in machine design and robotics, were corecipients of the first Harold E. Edgerton Faculty Achievement Award. The Award recognizes young faculty members for outstanding achievements in research, scholarship, and teaching.

Several changes in senior posts in the academic administration were announced this past year. New department heads announced during the year include Jerome I. Friedman, Department of Physics; Jack Kerrebrock, Department of Aeronautics and Astronautics; David N. Wormley, Department of Mechanical Engineering, and Fernando J. Corbato, Acting Associate Head of the Department of Electrical Engineering and Computer Science.

On July 1, 1983, the Department of Earth and Planetary Sciences and the Department of Meteorology and Physical Oceanography merged and became the Department of Earth, Atmospheric, and Planetary Sciences. William F. Brace has remained as Head of the new department and Peter H. Stone became Director of the newly created Center for Meteorology and Physical Oceanography.

Other changes in the academic administration announced during the year included the appointment of Nicholas A. Ashford, Director of the Center for Policy Alternatives; Emilio D. Bizzi as Director of Whitaker College of Health Sciences, Technology, and Management, succeeding Irving M. London who will continue to serve as Director of the Harvard-MIT Division of Health Sciences and Technology; H. Kent Bowen, Director of the Center for Materials Processing; Jeffrey Goldstone, Director of the Center for Theoretical Physics; Arthur K. Kerman, Director of the Laboratory for Nuclear Science; Thomas H. Lee, Director of the Electric Power Systems Engineering Laboratory; David Litster, Director of the Center for Materials Science and Engineering; Pauline Maier, History Section Head, Department of Humanities; James R. Melcher, Associate Director of the Electric Power Systems Engineering Laboratory; Ernest J. Moniz, Director of the MIT Bates Linear Accelerator; James Paradis, Head, Writing Program, Department of Humanities; Joseph Salah, Director of the Haystack Observatory; Marcus A. Thompson, Music Section Head, Department of Humanities.

Several changes in the Institute's central administration also were announced during the year. The administrative responsibilities which Professor Wadleigh carried as Vice President and Dean of the Graduate School have now been assigned to several officers of the Institute: Frank E. Perkins will assume responsibilities as Dean of the Graduate School in addition to continuing as Associate Provost; the Medical Department will report to Vice President Constantine B. Simonides; the Division of Comparative Medicine will report to Associate Provost and Vice President for Research, Kenneth A. Smith, and the Registrar will report to Jack H. Frailey, Director of Student Financial Services. Other changes in the administration include the appointment of John B. Turner as Assistant Provost (in addition to continuing as Associate Dean of the Graduate School); James D. Bruce, Director of Information Systems; Eric Johnson, Assistant Dean for Resource Development in the School of Engineering; Frederick J. McGarry, Director of Summer Session; Donna R. Savicki, Assistant Dean for Administration in the School of Engineering; and James D. Utterback, Director of the Industrial Liaison Program.

The Institute was saddened this year by the deaths of several longtime friends and colleagues. We miss their presence among us and are grateful for their contributions to this community.

John Chipman, professor emeritus of metallurgy, died on May 14, 1983 at the age of 86. He joined the faculty at MIT in 1937 as a professor of metallurgy, was appointed Head of the Department of Metallurgy in 1946 and remained as Head until he retired in 1962. He was

recognized internationally for his important contributions to the development of atomic power during World War II and for his applications of the theories of physical chemistry to steel-making.

Paul V. Cusick, a longtime member of the MIT administration (1944-1978), died at the age of 65 on December 15, 1982. During his career at MIT, he became a national leader among research university business officers and an authority on university-government relations. He served in a variety of financial administrative positions at the Institute, his last being Vice President for Fiscal Relations which he held from 1973 until his retirement.

Lawrence J. Heidt, associate professor of physical chemistry emeritus, died on April 4, 1983, at the age of 78. After finishing his doctoral work at Harvard in 1935, he joined the MIT faculty, teaching courses in general and physical chemistry until his retirement.

George J. Leness, a 1926 graduate of MIT, a national leader in the investment banking industry, and a former track star at the Institute, died on August 17, 1983, at the age of 80. A retired Chairman and Chief Executive Officer of Merrill Lynch, Pierce, Fenner and Smith, he played a major role in shaping the investment policies of MIT through his long service on the Investment Committee. He served as a member of the Corporation from 1949 to 1954, and became a Life Member in 1961.

David A. Shepard, a 1926 graduate of MIT, an internationally respected business statesman, and a loyal alumnus, died July 10, 1983, at the age of 80. A retired executive vice president of the Exxon Corporation, Mr. Shepard was a member of the MIT Corporation for 32 years, beginning as an Alumni Term member in 1951, becoming a Life Member in 1955 and Life Member Emeritus in 1977. He served on the Corporation's Executive Committee, and in doing so had the distinction of serving with four MIT presidents.

Alexander Smakula, professor of crystal physics emeritus in the Department of Electrical Engineering and Computer Science, died May 17, 1983, at the age of 82. Dr. Smakula came to MIT in 1951 as associate director of the Laboratory for Insulation Research under Dr. Arthur R. Von Hippel and subsequently founded and headed the Crystal Physics Laboratory. He was recognized internationally for conceiving the idea and the technology for permanent nonreflective coatings now used on almost all optical surfaces.

W. Van Alan Clark, Jr., member of the MIT Corporation since 1972, graduate and onetime faculty member of MIT, died July 16, 1983, at the age of 63. Retired president and chairman of the Sippican Corporation, Mr. Clark was an active philanthropist contributing not only personally to the support of MIT but also assisting greatly in securing corporate and foundation support.

Mrs. Helen F. Whitaker, an advocate of basic research and advanced education in the field of human health, died September 14, 1982, at the age of 76. A Life Member of the MIT Corporation, she was an early advocate of research and education in the life sciences. Along with her husband, she was a major benefactor of MIT, playing a major role in the expansion here of basic research in the health and life sciences and in the health professions.

Professor Emeritus Carroll L. Wilson, a member of the MIT faculty since 1959, died January 12, 1983, at the age of 72. A 1932 alumnus of MIT, Professor Wilson served as assistant to President Karl T. Compton until 1936. He was the first manager of the Atomic Energy Commission in the late 1940s and, as professor of management in the early 1960s, he founded and directed the MIT Fellows in Africa and Latin America programs. Renowned as a leader in the field of ecology and world energy supplies, he spent much of his career seeking solutions to problems with global dimensions.

Lester Wolfe, a member of the MIT Class of 1919 who went on to become an inventor, builder, innovative business leader, and patron of both the arts and scientific research, died July 6, 1983, at the age of 86. A benefactor of various scientific endeavors at MIT, Mr. Wolfe has supported research ranging from molecular biology to spectroscopy to archaeology. He also established the Kathlyn Langford Wolfe prizes for undergraduate and graduate students in materials science, the humanities, and the arts.

Statistics for the Year

The following paragraphs report briefly on various aspects of the Institute's activities and operations during 1982-83.

Registration

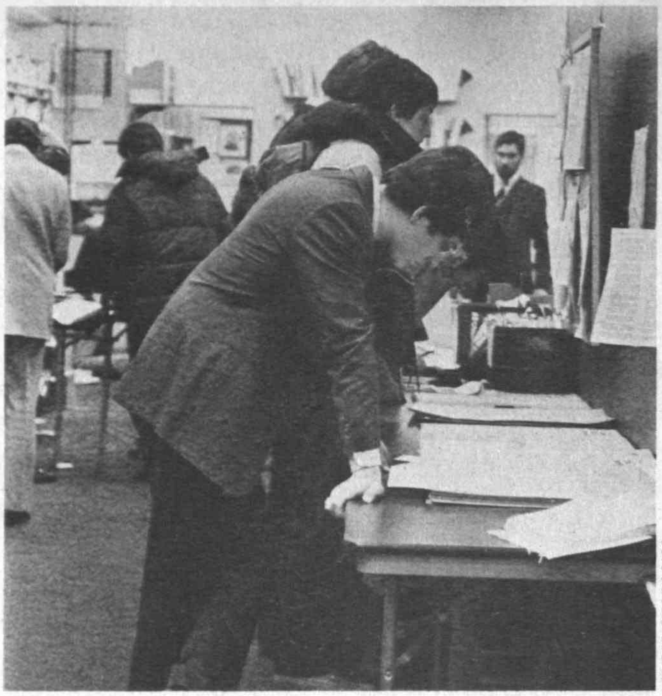
In 1982-83 student enrollment was 9,475, compared with 9,510 in 1981-82. This total comprised 4,619 undergraduates (compared with 4,562 the previous year) and 4,856 graduate students (compared with 4,940 the previous year). Graduate students who entered MIT last year held degrees from 394 colleges and universities — 231 American and 163 foreign. The international student population was 1,987, representing 11 percent of the undergraduate and 30 percent of the graduate population. These students were citizens of 96 countries.

Degrees awarded by the Institute in 1982-83 included 1,135 bachelor's degrees, 1,125 master's degrees, 67 engineer's degrees, 432 doctoral degrees — a total of 2,759.

In 1982-83 there were 1,977 women students (1,048 undergraduate and 929 graduate) at the Institute, compared with 1,879 (977 undergraduate and 902 graduate) in 1981-82. In September 1982, 266 first-year women entered MIT, representing 24 percent of the entering class.

In 1982-83 there were 968 minority students* (817

*Minority students include 314 Blacks (non-Hispanics), 18 native Americans, 182 Hispanics, and 454 Asian Americans.



LAURIE GOLDMAN

undergraduate and 151 graduate) at the Institute, compared with 929 (725 undergraduate and 204 graduate) in 1981-82. The first-year class entering in September 1982 included 265 minority students, representing 24 percent of the class.

Student Financial Aid

During the academic year 1982-83 the student financial aid program was again characterized by increases in the overall need for financial aid and in the aggregrate amount of grants made available. There was an increase in the amount of MIT loans awarded. Federally guaranteed loans obtained from commercial sources showed a significant decrease.

A total of 2,532 undergraduates who demonstrated the need for assistance (55 percent of the enrollment) received $12,319,800 in grant aid and $2,444,083 in loans. The total, $14,763,883, represents a 17 percent increase in aid compared with last year.

Grant assistance was provided by the scholarship endowment in the amount of $3,537,795; by outside gifts and Federal allocations to MIT for scholarships in the amount of $1,549,976; and by direct grants to needy students totaling $3,052,013 (a 13 percent increase over last year). Scholarship assistance from MIT's own operating funds was provided to the extent of $4,007,557 (a 52 percent increase over last year's level and the largest allocation ever). The special program of scholarship aid to minority group students represented an additional $172,459 from specially designated funds. An additional 514 students received grants from outside agencies, irrespective of need. The undergraduate scholarship endowment was aided by the addition of new funds which represented an increase of about $3,291,904 and which raised the principal of the endowment to $33,804,455.

Loans totaling $2,444,083 were made to needy undergraduates — a 21 percent increase over last year. Of this amount $509,349 came from the Technology Loan Fund and $1,934,734 from the National Direct Loan Fund. Not included in the foregoing summary is an additional $6,029,753 obtained by undergraduates from state-administered Guaranteed Loan Programs and other outside sources. This represents an 18 percent decrease in the use of these programs over last year, reflecting a moderate tightening of eligibility requirements.

Graduate students obtained $1,015,635 from the Technology Loan Fund, about half of which was loaned to international students and did not qualify for the Federal interest subsidies and guarantees available under the Guaranteed Student Loan Program. In addition, $322,580 was loaned by MIT under the Guaranteed Student Loan Program. The total, $1,338,215, represents a 35 percent increase over last year's level. Graduate students obtained $3,441,670 from outside sources under the Guaranteed Student Loan Program — 15 percent below last year's level. The total loaned by MIT to both graduate and undergraduate students was $3,782,298, a 25 percent increase over last year's level.

Career Services and Preprofessional Advising

For students in many disciplines, 1982-83 was a difficult year to look for a job. Employers sent out few recruiters and were slow in making offers. Because of the softness in the price of oil and the presence of excess capacity in many sectors of the chemical industry, chemical engineers — normally in demand — felt the pinch particularly. Not all students have reported their postgraduation plans, but it is clear that a number of chemical engineers had not found jobs in June. Firms reporting on their offers to students reported only one-fourth as many offers to chemical engineers as in 1981-82. The impact of the recession in other fields, while real, was less spectacular.

Demand was strongest in electrical engineering and computer science. The demand came from every sort of employer, from electronics firms to investment banks, from government laboratories to entrepreneurs hiring their first employees. If some firms were not hiring — many had hiring freezes — there were many others which were.

Altogether, 405 employers made recruiting visits, compared with 450 in 1981-82. A total of 1,401 students had 9,675 interviews. Anxiety about the job market prompted students to have more interviews. The average number of interviews per student was 6.9, compared with 6.4 in 1981-82, 5.8 in 1980-81, and 4.9 in 1979-80.

There was a decline in the number of applicants to medical school. A total of 101 candidates filed applications, down from 130 in 1981-82. They included 69 seniors, 13 graduate students, and 19 alumni. Preliminary returns indicate that 78 were accepted. Information is not available yet on the number of students proceeding to graduate study in other fields.

Physical Plant and Campus Environment

MIT's first residence for single graduate women opened in February with the completion of renovations to the building which formerly housed the medical infirmary. It provides accommodations for 45 women in a variety of singles and doubles with lounge and kitchen-dining facilities on each floor. This residence, Green Hall, was dedicated on June 10, 1983, in honor of Ida Flansburgh Green of Dallas, Texas, who has long been a friend and benefactor to women pursuing graduate studies at the Institute.

Other projects completed during the year included the Edward Pennell Brooks Center, a residence and conference facility in Dedham, adjacent to Endicott House; renovation of the lower floors of the Sloan Building on Memorial Drive and the Plasma Fusion Center and Tandem Mirror Facility in the former Nabisco Building on Albany Street.

Projects under construction are the EG&G (Edgerton, Germeshausen, and Grier) Education Center, adjacent to the Fairchild Electrical Engineering Building, to be completed in the fall; the Arts and Media Technology Building on Ames Street, scheduled for completion in the spring of 1984; and the complete rehabilitation of the undergraduate chemistry laboratories on the top floor of Building 4, scheduled to be completed for the 1983 fall term.

The first phase of the Microsystems Technology Laboratories project, which involved vacating Building 39 to make way for construction of the new facility, was successfully completed in May 1983. The Information Processing Services computers were moved to renovated space in the former Supersonic Laboratory on the West Campus. Computer user services and administration were moved to renovated space in the former medical department area in Building 11 and Building 4, while the Industrial Liaison Program was consolidated on two floors of the Suffolk Building on Main Street. All these moves were made without extensive interruption of computer services.

Projects in the design phase and scheduled for a construction start during the summer of 1983 are the Microsystems Technology Laboratories facility in the vacated Information Processing Services building; renovation of the upper floors of the Sloan Building; major renovation of 175 Albany Street to accommodate the Nuclear Magnetic Resonance (NMR) facility and Plasma Fusion Center activities; and the renovation of the remaining space in Building 11 to house the Joint Computer Facility and Project Athena on the first floor and the Graphic Arts Copy Center in the basement.

The program to install smoke detectors in all dormitory rooms and apartments is near completion. This effort, conducted by the Safety Office and the Housing Office, was required to meet new city and state fire safety codes.

Implementation of the East Campus-Senior House residents' proposal to install kitchen/dining facilities within their houses is well under way, with completion expected by the end of the summer. With these new community kitchens—17 in total—the residents will no longer be required to participate in the commons program.

The dining program completed its last year of transition. Next year all four classes in those houses with dining halls will participate in the commons program. Changes continue to be implemented, wherever possible, in an attempt to meet the ever changing needs of students. The contributions of the House Commons Committees, Dining Advisory Board, students, and employees have been most significant.

A new food service facility was opened in February on the first floor of the Sloan Building. This unit, operated as an adjunct to the Faculty Club, serves light lunches, snacks, and beverages Monday through Friday. It has been well received by the community and averages approximately 700 customers each day.

Finances

As reported by the Vice President for Financial Operations and the Treasurer, the total financial operations of the Institute, including sponsored research, amounted to $588,702,000, an increase of 14 percent over 1981-82. Education and general expenses—excluding the direct expenses of departmental and interdepartmental research, and the Lincoln Laboratory—amounted to $255,541,000 during 1982-83, compared to $227,165,000 in 1981-82. The direct expenses of campus departmental and interdepartmental sponsored research increased from $143,537,000 to $149,478,000; the direct expenses of the Lincoln Laboratory's sponsored research increased from $144,726,000 to $183,683,000, largely because of increased subcontracts and equipment purchases.

For the second time in recent years the financial operations of the Institute were not in balance, with expenses exceeding income by approximately $3 million. Current revenues used to meet the Institute's operating

MARK WILSON

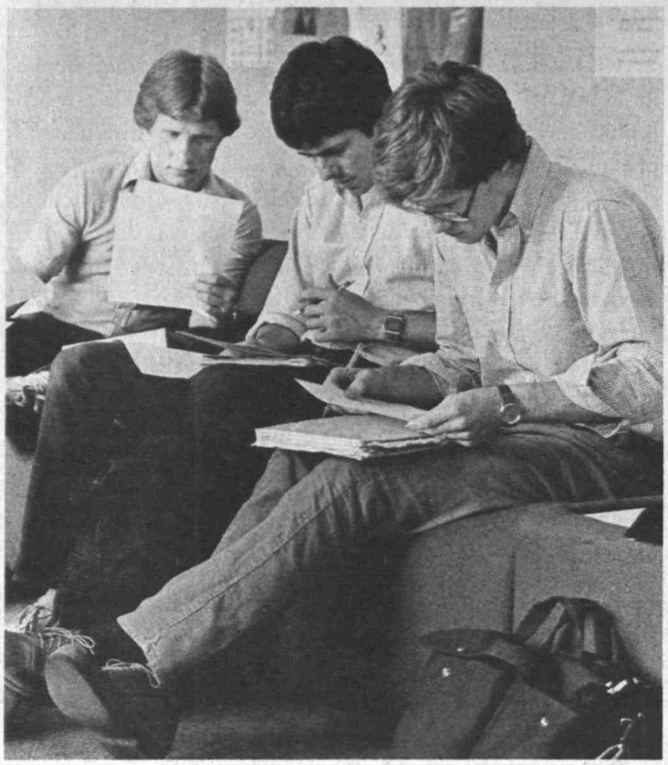
expenses totaled $578,382,000, augmented by $7,214,000 in unrestricted funds. The remaining $3,106,000 needed to meet expenses was met from a special distribution to funds from the reserve of investment income held for future distribution.

The construction program of the Institute continued to make progress in 1982-83, with book value of educational plant facilities increasing from $278,949,000 to $288,392,000.

At the end of the fiscal year, the Institute's investments, excluding retirement funds, students' notes receivable, and amounts due from educational plant, had a book value of $514,808,000 and a market value of $767,228,000. This compares to book and market values of $463,786,000 and $539,736,000 last year.

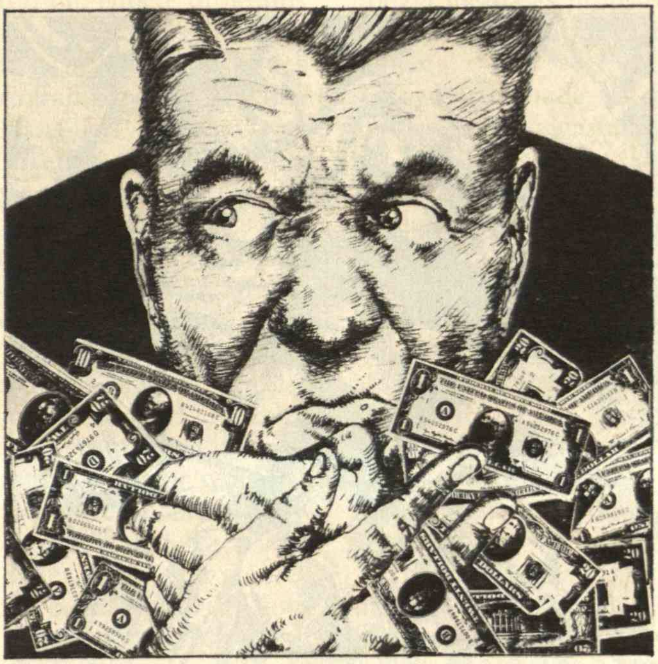
Gifts

Gifts, grants, and bequests to MIT from private donors increased by 22 percent in 1982-83 to a total of $50,025,000, as compared to $41,055,000 in 1981-82. This is the largest amount of gifts received in a single year in the history of the Institute. The Alumni Fund reported gifts of $8,662,000 for the year, a new record.



BRADFORD HERZOG

What the administration did was order a 12 percent across-the-board cut in basic research outside the Department of Defense.



That group threatened to do more. Milton Friedman, the Nobel laureate who was the economic godfather of the right, caused the ivory towers to tremble by suggesting that the National Science Foundation be eliminated. According to Friedman, the private sector should be funding its own research in universities. Because it lacked market goals, government-sponsored research produced mostly waste. Friedman's views were regarded as farfetched even by presidential staffers. But what the administration did was order, as part of its fiscal 1981 budget-reform package, a 12 percent across-the-board cut in basic research outside the Department of Defense.

In near-panic, the National Academy of Sciences called a "colloquy" in October 1981 to protest the dangers. Ever since Vannevar Bush had introduced the idea of science as the "endless frontier" in 1945, the community, and the country, had accepted the premise that federally funded basic research led to technology, which in turn guaranteed American prosperity. Thus, without any guideposts from the past, the technical establishment couldn't quite figure out the ramifications of the funding changes the Reagan administration was introducing.

The basic problem, as many scientists saw it, was that no one on the incoming Reagan team was really conversant with science and technology. "When this administration came into power," recalls political scientist Jurgen Schmandt of the University of Texas, who was then studying acid rain at the Environmental Protection Agency (EPA), "I was amazed at how ignorant they were on matters of science and technology. It was blatantly visible that someone could still in this day and age get elected with a team of advisers not having either experience or knowledge of science in national and international affairs. They didn't understand the basic structural changes science and technology had made on institutions. While we knew they wouldn't be interested in environmental matters, we might have thought they would at least be intrigued by the power of science to improve productivity. But they thought little about the technological forces that keep our economy going, how the chain of innovation moves, how it really starts."

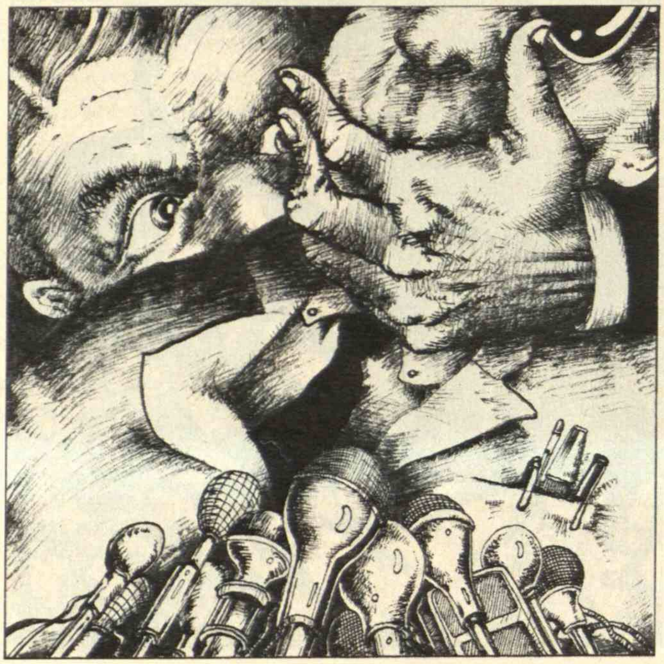
But if the administration had no concept of "science policy," it did have definite ideas about, say, energy policy and environmental policy. Translated into action, these ideas meant first "privatizing" energy research and development, as bureaucrats had no understanding of market demands and requirements. Second, conservatives wanted to roll back the regulatory express, arguing that the environmental zeal of past administrations had stunted industrial growth and vigor.

The administration made no bones about its intention to put economic factors ahead of statutory considerations in protecting workers and the environment. EPA head Anne Gorsuch (later, after her marriage, Burford) and her toxic-waste chief Rita Lavelle instructed underlings to consider the impact on industrial profits when they acted on threats of hazardous waste to human health.

As those policies started to take practical shape, a new science adviser emerged. After much prodding from congressional Republicans, the administration appointed an unknown by the name of George A. (Jay) Keyworth II, a physicist at the Los Alamos National Laboratory with scant experience in science policy, as assistant to the president for science and technology. A protege of conservative and controversial nuclear physicist Edward Teller, and a personal friend of many of Ronald Reagan's top California advisers, Keyworth adhered to the free-market philosophies of the Reagan team and made it clear that his job was not to serve any scientific establishment. Keyworth set up a lean Office of Science and Technology Policy nowhere near the size and shape that the transition team had envisaged. Thus,

The administration proposed to restrict communication of technical information deemed strategically sensitive.

the technological establishment still saw no sign of a strong, sympathetic presence in Washington. But Keyworth at least was a member of the American physics community, which more than any other discipline had shaped science advice at the presidential level.



An Emerging Conservative Philosophy

While Keyworth was settling into his low-key post, conservative thinkers started to develop a philosophy for dealing with science and technology. In its major report *Mandate for Change*, the Heritage Foundation, often called the administration's think tank, issued a set of principles to guide the funding of science. The less conservative, older American Enterprise Institute commissioned a paper on the matter—now widely quoted—from University of Massachusetts economist Simon Rottenberg.

Both institutions concluded that government could legitimately support truly fundamental research. It was, they implied, an economic "externality" that could benefit society rather than any single private institution. By contrast, Rottenberg maintained, applied research administered by government agencies would produce mainly "mischief" in the marketplace. Therefore, applied R&D in areas outside defense and space were, and always had been, lost, indulgent, misguided causes. The reports presumed that smaller government, but also government more sympathetic to business, would best ensure the health of the economy and the social system. If government funding of applied research were cut, taxes could be reduced and industry would thus be motivated to invest in new technology. The market, in other words, would choose the priorities—not some bureaucrat in Washington seeking wider turf on which to waste taxpayers' money.

When possible, government funding of science and technology would be shifted to the private sector. For example, research on photosynthesis, according to Rottenberg's thinking, would be funded mainly by agribusiness or energy corporations. Research connected in any way with the development of new drugs or treatments would be the fiscal responsibility of the pharmaceutical industry. New materials for the electronics industry, no matter how basic the foundation, would be funded by the industry itself.

But while the Reagan team sought to shift control of research and technology to the private sector, it began setting limits on scientific freedom that the technical establishment found disturbing. The administration proposed to restrict communication of technical information deemed strategically sensitive. It also moved to censor writings by former officials on subjects relating, however loosely, to national security. In doing so, it threatened to preclude the open debate that critics saw as crucial to a democratic society.

Some "purer" conservatives disapproved. Don Doig, an associate policy analyst for the conservative Cato Institute in Washington, declared in a report last March that "politicization is not a problem unique to the Reagan administration, though it is apparently growing more serious than in previous administrations. Historically, expansion of domestic military expenditures and heightened national security concerns have tended to produce politics destructive of freedom of speech and of the press." The chide seemed a bit oblique, but what Doig was saying was that the Reagan administration was treading on grounds threatening to individual freedom.

And for all the rhetoric about reducing government involvement in people's lives, what was one to make of the administration's proposal to install "hot lines" from hospital wards to Washington? These were to enable hospital staff opposed to abortion and other controversial medical practices involving the termination of life to inform Washington of such cases.

One of the more stunning reversals affected the basic science budget.

Paradoxically, the administration ended programs that might enable society to consider the ethical dilemmas posed by modern medical technology, such as the bioethics research program operated by the National Institutes of Health. (This program was later reinstated.) The administration also ordered an end to a small science and society program at the National Science Foundation.

In fact, the administration rapidly began to display a lack of consistency on technological issues where day-to-day politics dictated a compromise with ideology. One example was the Clinch River breeder reactor, an outmoded power plant that the nuclear industry itself saw as a dubious investment. The Heritage Foundation wanted the government to drop its support for the reactor, but the industry wouldn't take over its construction. However, Clinch River was in Tennessee, the state represented by Senate majority leader Howard H. Baker, and Baker wanted the project for its pork-barrel benefits. So the government continued to fund it—at least until late last year, when the Senate killed the project.

Nor did economic conservatives think much of the Synthetic Fuels Corp. (SFC), a government agency with an $88 billion program of contracts, loans, and loan guarantees. But lobbyists from the oil industry and states where SFC had begun to fund projects succeeded in preserving the program.

The Loss of Ideological Innocence

From 1982 onward, as it moved deeper into the responsibilities of governance, the administration began losing its ideological innocence. Conservatism is built on the premise of preserving a past, and 30 years of liberal institutions did form a tradition of sorts. While the Reagan administration stuck by internationally unpopular policies, such as refusing to ratify the Law of the Sea Treaty (which gave Third World countries some political control and access to some Western technology in exploiting minerals from the oceans), it did backtrack from early positions on a number of issues.

One of the more stunning reversals affected the basic science budget. In his early speeches, Keyworth defended administration science cuts by contending that mediocre science needed to be culled from the system, and that therefore austerity was a blessing the system needed. But by 1982, Keyworth was heralding one of the largest National Science Foundation budget increases in history, as well as a rise of more than 20 percent in the Defense Department's research budget.

Keyworth made no more speeches from then on about scientific waste. In fact, by last fall he was saying this: "In absolute terms, there's just not enough research funding, particularly unrestricted funding, available for agricultural research. . . . I'd like to see agricultural scientists be able to turn to single sources of major support with the Department of Agriculture." The administration even found itself opposing the fertilizer and agricultural-chemical industry in its attempt to reorganize the Agricultural Research Service (ARS). The agricultural-chemical interests wanted to preserve the more traditional, chemically intensive crop-production system, while the ARS was hoping to move into more exciting areas of molecular genetics.

The administration also drew back from its original insistence that the government had no business developing new technologies for the private sector. In early 1983, it announced that the Defense Department would launch a major program to develop the next generation of superfast computers, to meet the competition from Japan. Former Nixon science advisor Edward David saw this tendency as nothing surprising. The government, he said, had always used the Defense Department in the same way that Japan uses its Ministry for International Trade and Investment.

The Reagan administration at first stonewalled other issues such as toxic waste. But by 1983 it began yielding to scientific advice, including one report from Keyworth's own office, and to public opinion, deciding that action on that issue was needed. The EPA scandals had something to do with that. But clearly the administration was also yielding to scientific fact and international opinion.

In another area, it initially eschewed government support for applied research along the lines Rottenberg drew up. But in 1983 it established a new directorate of engineering at NSF without really making clear just how engineering is an economic "externality."

And observers could only smile when the White House was forced into a total about-face in science education. After attempting to eliminate the science education program at NSF, it bowed to public concern over the alarming decline of the quality of teaching in high schools by offering new bills designed to

Without any recanting on fundamental philosophy and ideology, changes have been tied to pragmatic considerations.

infuse funds into the field. Last October, a new directorate of science and engineering education was established at the foundation. On a broader scale, the consensus now seems to be that the Education Department—a prime target for conservatives early in the administration—no longer needs to be dismantled. The government now has a powerful fiscal and policy role to play in improving the education of high-school students. Its role need not be intrusive—it need not prescribe curricula, as conservatives have always feared. But through funding initiatives it can supply innovative ideas that school districts and the private sector can then choose to implement or ignore.

Finally, if holdouts remain unconvinced that the Reagan science and technology ideology has changed, one of EPA Administrator William D. Ruckleshaus's comments on the agency's role in funding new technologies for controlling pollution should be persuasive. "For a relatively small public investment," he told *Business Week* last August, "there may be very large social, economic, and environmental payoffs. And it may well be that nobody will develop (new technology) if we don't."

No 1960s Democrat could have improved on a statement like that. In fact, there is nothing wrong with the government's developing ideas, concepts, and hardware for the private sector to exploit for the good of the public. The problem has always been defining the public interest, along with preventing incompetent bureaucrats from bottling up the process of technology transfer. One program the Reagan government has never touched—or perhaps even noticed—is the technically acclaimed fertilizer-development activity by the Tennesesee Valley Authority in Muscle Shoals, Ala. Once a federal gunpowder factory, Muscle Shoals now conducts all the R&D on fertilizers that the industry needs. It does it so well that the industry does almost no research of its own, and private-sector ideologues have no complaints.

"And so," observes William D. Carey, executive officer for the American Association for the Advancement of Science, "we have seen a remarkable series of exceptions to Reagan's ideological rules. It now takes the form of special favors toward the funding of basic science, all dressed up in pragmatic rhetoric. We are now asked to believe that basic science is going to stimulate restoration of economic strength and recovery from unemployment. This is hardly to be believed because of the time constraints that go into basic research."

Concludes Carey on the turnaround: "It's not easy to rationalize the picture, but I would have to say that the strings have been loosened in a number of significant ways. Without any recanting on fundamental philosophy and ideology, changes have been tied to pragmatic considerations. To that extent, Keyworth has really been remarkably successful in finding reasons for staying within the orbit of conservative thought while moving government back to the center."

Obviously, pragmatic reasoning, and in some cases Keyworth's science advising, have superseded ideology. And that has been the case across the board, as problems are seen as genuine and not the product of collectivist plots. Thus, because of public opinion, a whole policy can shift.

Cynics might say that the reason the Reagan administration has turned pragmatic in its science policies is that it is facing an election year, and it needs to start showing some fruits from investments in R&D. But there's more to it that than that. One of the major debates of 1984 will focus on industrial policy. And that is precisely the issue that conservative think tanks are beginning to address.

Issues for the Think Tanks

At the American Enterprise Institute, a team headed by historian and former journalist Claude Barfield is trying to formulate a global perspective of science and technology through a program entitled "Competing in a Changing World Economy." At the Heritage Foundation, meanwhile, senior energy analyst Milton R. Copulos has been put in charge of a new science and technology program.

The AEI project will study ways of boosting the competitiveness of American goods through, say, export incentives for high-technology industries. Barfield is asking whether current tax incentives for industry R&D are really working, whether current antitrust policies inhibit joint R&D efforts, why the number of patents granted to U.S. investors has dropped so much in recent years, and to what degree government should promote technological innovation and market development. Barfield admits that these are frequently asked questions. But he hopes that the scholars and other experts he engages can find some new answers.

The campaign debate this election year will implicitly center on science, technology, and social and economic policy.

Barfield makes no bones about dissociating himself from any comparison with the Heritage Foundation. "The main difference between us and Heritage is that there is no institutional policy here," he explains. "Heritage tends to write things as a Heritage Foundation position. Here, there is no AEI position." In this sense, the AEI has moved to a centrist position in public policy just as the Reagan administration has.

At Heritage, Copulos feels that he is holding the fort for old-fashioned conservatism in the face of all the administration's policy retreats. He believes he is designing an industrial policy behind which any true conservative administration can stand. What Copulos wants to do is privatize, as much as possible, R&D that is now sponsored by the government. Typical of his schemes is one to foster private investment in R&D so that as many people as possible can share in the rewards. What he is proposing is a "risk investment trust account" (RITA). RITA would function in much the same way as an individual retirement account; it would not be taxed up to a certain amount yearly. In addition, its internal cash flow would not be taxable. RITA would be used to raise capital for high-risk ventures.

"An individual inventor," Copulos says, "would go to one of these venture entities and say he's got an idea. He needs such and such amount of money to go. The RITA funds could not go into existing stocks. The reason is that trading in existing stock just moves money around and doesn't create new capital. The idea is to create a pool of risk capital. What's in it for the investor, of course, is that if the fund is managed well it may be that a certain percentage of projects will be successful. The RITA would also be regulated by the SEC to protect the investor against frauds."

Copulos has other ideas for antitrust policy (on which the administration has submitted new legislation), patent policy, and private funding of big ventures such as the Clinch River reactor, which he opposed from the start. But more important than his specific ideas is the fact that he is working on them all. This activity indicates that conservatives are finally giving thought to science and technology policy.

Certainly the campaign debate this election year will implicitly center on science, technology, and social and economic policy. The sharpest focus will probably be on industrial policy, since it embraces all elements from basic research to concepts of regional planning and development. This focus is important because of the vast industrial changes occurring within the country. *Forbes* magazine, for example, says that the country is doing something it calls "molting"—shedding its former smokestack way of thinking and attempting to fit for size the patterns and fabrics designed and manufactured by computers and telecommunications networks.

The Democrats are evolving several models of reindustrialization, but the one drawing most attention is that of Harvard Business School professor Robert Reich. He calls for considerable government involvement in the industrial culture, through higher mandated wages for workers, high taxes, especially for the wealthy, food assistance for those who need it (because a healthy society works better), and job retraining. "A social organization premised on equity, security, and participation," says Reich, "will generate more productivity than one premised on greed and fear."

The highly conservative Rockford Institute, of Rockford, Ill., calls the Reich formula "mild-mannered collectivism"—an insult to the dignity of Americans. "Fortunately," writes the institute's Allan C. Carlson in its publication *Persuasion at Work*, "we still have an alternative. The historic character of the American people has weakened considerably, but there remain substantial portions of the entrepreneur-

ial, or bourgeois, virtues. Apparently, such folks are rarely found in Harvard Yard. However, many reside in the nation's suburbs, medium-sized cities, and towns. These are individuals who still take responsibility for their lives, still plant and save for their futures, still believe in progress, innovation, and improvement, and still find 'community' in their churches, clubs, neighborhoods, and families. Moreover, the market forces of demand and supply clearly remain resilient enough to respond to the capital investment, insurance, and educational requirements raised by the international challenges, provided that the politically determined roadblocks of government subsidy and regulation protecting existing structures are removed. In short, we can avoid the universal embrace of the socialist personality that Professor Reich proposes and still recover our economic momentum."

Technology in the Presidential Campaign

Plainly, the ideological lines are drawn. This election year of 1984 should broaden the debate over how the country adapts to the changing world of technology. The Reagan "science policy" is now pretty well established as business as usual. Instead, technology, and who does what part in it, will be the issue. This debate will concern political philosophy.

In a seminar at George Washington University last spring, Harvey Brooks, professor of technology and public policy at Harvard University, took a lengthy look at the the Reagan administration's impact on the system of support for science and technology. Despite the early flourish, he said, the Reaganites had wrought little change in the basic structure. In terms of the private-sector/public-sector debate over science and technology, Brooks could see only "greater public-sector involvement in research and development in a wider and wider range of topics." Science and technology already have too much public impact on the way governments are run all over the world for drastic changes to be possible, he argued. Joint international planning is becoming more and more necessary in a global system tied together by economics, finance, and investment. But, said Brooks, "my greatest fear is that, because of trade frictions and increased preoccupation with national security in a narrow military sense, things may move in an exactly opposite direction, to the great detriment of world science, and ultimately the world economy."

And he added: "The whole world is at a critical stage in the evolution of human societies. It is in the process of being integrated into a world society at a time when the forces of fragmentation and local nationalism and ethnocentrism are greater than ever. The problems cannot be solved by science and technology, but neither can they be solved without them. The difficulty lies in deciding the proper mix and relationship between technical and social change. Of all the challenges to science and policy that lie ahead, this is the most severe and most puzzling."

It is quite unlikely that this year's politicking, and a second Reagan administration, if it emerges, will encourage any deep insight into these problems. Nevertheless, science and technology will almost certainly occupy a position closer to stage center than they have in any previous presidential campaign. So it is instructive to ask how the administration's record will appear during the days leading up to November 6. Based on its record over the past year, we can expect the White House to make the following science and technology proposals in its election-year budget:

☐ A new thrust into space, possibly with early work on developing a space platform, leading to at least the thought of lunar colonies in a couple of decades.

☐ Continued militarization of space, promising grand initiatives in aerospace and electronics R&D.

☐ A surge of interest in agricultural research, technology, and conservation. Agricultural problems really worry the administration. The danger of soil erosion, for example, is now widely recognized as closely tied to future farm economics.

☐ A methodical environmental research program, more sensitive to public opinion, but placing economic impacts ahead of social and ecological effects. Conflicts, in other words, will remain.

☐ Continued growth in basic-research programs. George Keyworth used to insist on "excellence and pertinence" as the criteria for a policy. These qualities are now assumed to have spread by some miraculous two-year process, and where funding is concerned, the administration is convinced that more is better.

Outside the strict budget process, we can expect other hints of the Reagan policy on science and technology. A continuing standoff seems likely between administration defense hawks and the academic community over communication of sensitive research findings.

What the administration will notice in 1984, and try to stimulate, is evidence from research agencies that their programs are contributing to the economy, innovation, and productivity. We can expect to see growing evidence of the major contribution of the conservative revolution: closer and closer integration of economics with science and technology. After many decades, policymakers are doing a better job of bringing the two together. That, by itself, is an achievement.

WIL LEPKOWSKI is a senior editor of Chemical and Engineering News.

After years of dreams, debates, and ingenious but sporadic efforts, new technology is moving the search for extraterrestrial intelligence a huge step forward. We are ever closer to answering that age-old question: are we alone in the universe?

Renaissance in the Search for Galactic Civilizations

BY EUGENE F. MALLOVE

IN 1900 the French Academy of Sciences offered 100,000 francs—the Pierre Guzman Prize—to the first person establishing communication with a world other than Mars. So certain was the existence of martians that communicating with them seemed too easy to deserve a prize.

Scientists' view of the prospects for contacting extraterrestrials has matured enormously since that era of perceived martian canals and presumed martians. We now know, of course, that there are no other advanced civilizations in our solar system. Experiments by the Viking landers in 1976 at best hint at the possibility of microbial life on Mars—and the results may have less lofty explanations, such as unusual inorganic chemical reactions that mimic metabolic processes. The irrefutable discovery of even microbial martian life, evolved independently from life on Earth, would point to the likely plentitude of organisms in the universe. But while arguments may continue about whether microbes exist on Mars, humankind must look to the 300 billion stars in our own Milky Way galaxy, or to the billions of galaxies beyond, if we are truly to contact our biological kin.

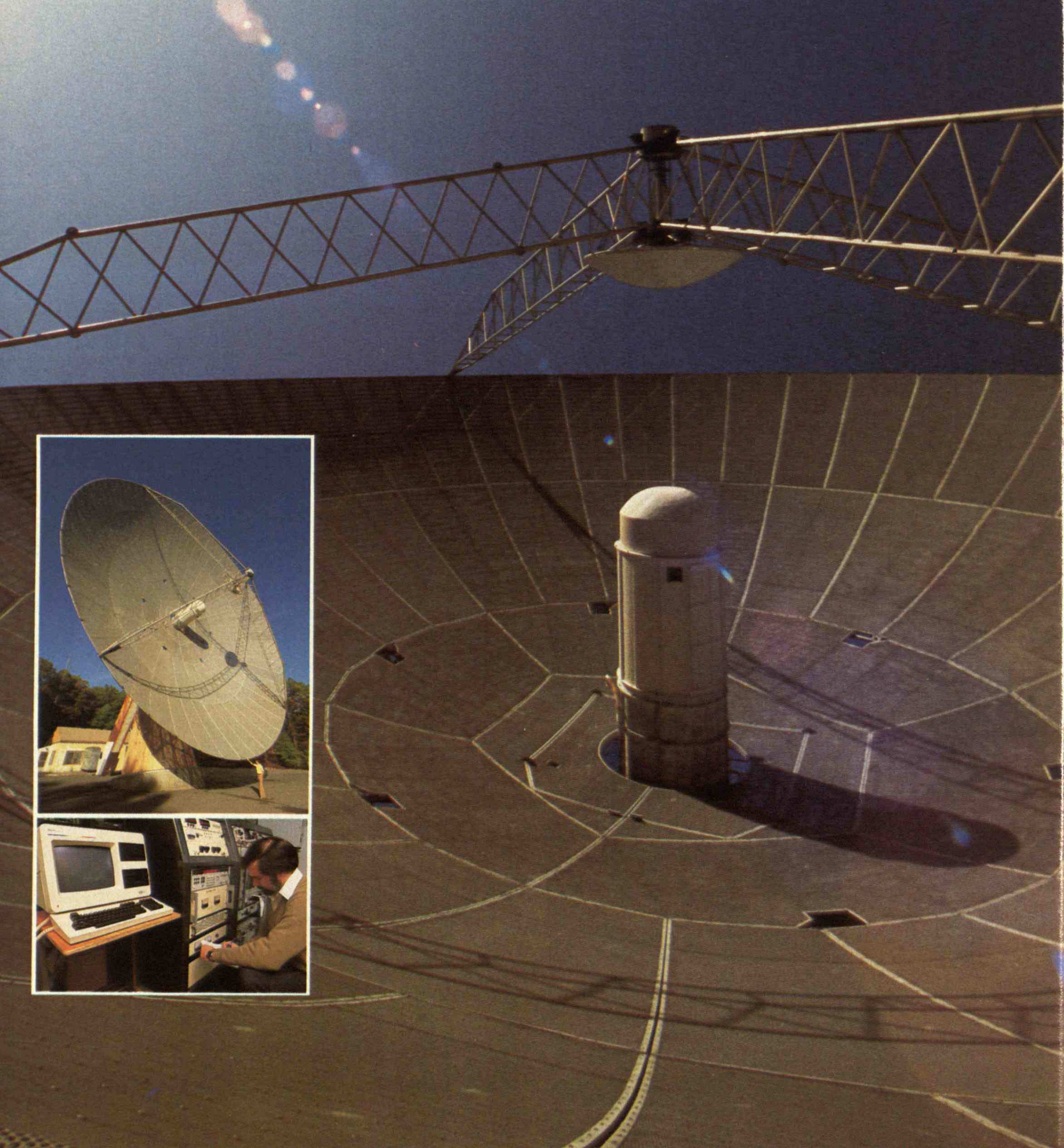
Since the Milky Way is at least 10 billion years old and our solar system only half that, civilizations elsewhere could be many millions of years older than our own. Would the wisdom of age cause them literally to shine their beneficence upon us via radiations that we could someday detect? "It may be that if we just point our antenna at the right piece of sky, and tune to the right channel, we will discover signals giving us knowledge that other beings have been storing for eons," says Thomas McDonough of the Planetary Society. "Even if we could not decipher them, just knowing of one other civilization advanced enough to broadcast radio signals could be vital." Receipt of one such signal would show that a planetary culture could overcome the problems of its youth and survive to old age.

Optimists in the search for extraterrestrial intelligence (SETI) feel that a renaissance is at hand. Listening efforts now underway or planned go technologically far beyond earlier tries. These efforts feature sophisticated yet economical microcomputer-controlled signal-processing devices coupled to radio telescopes, a system that greatly speeds up the painstaking process of scanning the heavens.

"The greatest obstacle to the success of radio searches has not been lack of sensitivity to weak signals or too-narrow coverage of the sky, as most imagine," says Frank Drake, SETI pioneer and astronomy professor at Cornell University. "Rather, it has been our inability to study,

PHOTO: FRANK SITEMAN

In the countryside near Boston, Project Sentinel's radio telescope listens around the clock in the most sensitive and comprehensive cosmic search yet.



Today's radio telescopes, like this 84-foot dish used in Project Sentinel, could detect beams sent from the other side of the galaxy. But the real advance in SETI is the development of economical computerized spectral analyzers that process incoming signals. Paul Horowitz of Harvard, standing in front of the dish, is chiefly responsible for Sentinel's analyzer, which scans more than 131,000 radio channels at once. Already the most sophisticated system in operation, it will soon be upgraded to scan 8.4 million channels. The author is shown with the analyzer, dubbed Suitcase SETI because of its small size and portability. (Photographs: Frank Siteman)

"With apparently billions of opportunities for life to arise in our galaxy alone, it would be astounding if we turned out to be the sole example of intelligent life."

at any given instant, a large sampling of frequency channels of the most promising portion of the radio spectrum." However, the new computerized signal processors allow scientists to search on tens of thousands, and soon millions, of channels simultaneously. They also permit almost instantaneous recognition of signals as noise or message, so vast quantities of data need not be stored for automated or manual processing. Current SETI programs project a 10-million-fold or greater increase over past efforts in the frequencies and directions to be searched in the next decade.

The National Aeronautics and Space Administration, after years of neglect, is moving ahead with the largest SETI program ever. (*See "NASA's SETI: Bigger Is Better," page 56.*) NASA's budget includes $1.5 million annually for a proposed multiyear effort. Researchers at NASA's Ames Research Laboratory, the Jet Propulsion Laboratory, and Stanford University are currently building the "next generation" of signal analyzers and other instruments for the search. Some listening for alien signals will be done as the equipment is tested, but the major searches will begin in 1988.

In the countryside just outside Boston, however, "Project Sentinel" is working around the clock right now. Sponsored privately by the Planetary Society, this is the most systematic and exhaustive cosmic search yet. Paul Horowitz, a professor of physics at Harvard University who has emerged as a leader in SETI, is chiefly responsible for the technology behind the project. "The system," he says, "accomplishes more in one minute than would have been done in 1,000 years with the first receiver constructed specifically for SETI, during the pioneering Project Ozma of 1960."

Likelihood of Life

SETI researchers base their conviction that other civilizations exist on several factors. First is the idea that many if not most stars are attended by planets. This idea received an important boost late last year. Scientists using the Infrared Astronomical Satellite (IRAS) detected what seems to be a planetary system forming around Vega, one of the brightest stars in the sky and located 26 light-years, or about 150 trillion miles, from Earth. This discovery provides the first direct evidence that solid objects of substantial size exist around a star other than our sun. (*See "Prospecting for Planets," page 59.*)

Another supporting factor is that laboratory experiments have shown how easy it is for the organic building blocks of life to form. Complex organic molecules form in abundance when scientists pass ultraviolet light or electric discharges through a flask containing the simple constituents believed to have comprised the early atmosphere of Earth. What's more, radio astronomers in the last decade have detected prodigious quantities of organic molecules in the interstellar medium. More than three dozen different molecules have now been identified, often in interstellar clouds light-years across. Thus, many scientists believe that life owes even more to the workings of stars than earlier suspected. Not only have the violent deaths of stars in supernova explosions synthesized all elements heavier than helium; the elements have organized themselves in space to form organic molecules that might have played a direct role in the evolution of life on planets.

"This means that a suitable habitat for life and a mechanism for its origin may exist near many of the billions of stars in our galaxy," says Horowitz. "Thus, the galaxy may be teeming with life and technology. But even without relying upon detailed speculations as to the probabilities of planetary formation, chemical and biological evolution, and the rise of intelligence, technology, and the like, we can observe that, in all of nature's variety, there is no phenomenon that happens only once. With apparently billions of opportunities for life to arise in our galaxy alone, it would be astounding if we turned out to be the sole example of intelligent life."

However, there are critics of the search for extraterrestrial intelligence. Their main argument is that if life is so prevalent and antique, why don't we see alien visitors all around us, since interstellar travel should have been available to them for millions of years? These critics cite calculations showing that if a single civilization set out to colonize the galaxy, even at the snail's pace of primitive interstellar craft, the entire whirlpool of stars could be inhabited in a small fraction of the galactic lifetime. Others have imagined self-replicating "von Neumann machines" flung into space by aliens. These artificially intelligent probes would use stellar resources to duplicate themselves exactly, with a mission to explore ever-increasing territory in the galaxy. If we see no evidence of such probes, either the original extraterrestrials never existed or they came to grief early in their technical development. The law of large numbers requires an almost unimaginable constraint on the movement of aliens for them or their machines not to be here.

SETI researchers offer a number of explanations for the fact that no one has found any concrete evidence of the existence of aliens. Perhaps such beings have tried to colonize new areas but their efforts have been restricted in direction and extent. Advanced cultures might even find that, with the contentment of age, they no longer seek new physical frontiers. SETI researchers hope, of course, that these cultures have not become so introverted that they have forgotten to offer greetings to other struggling civilizations. John Ball, a radio astronomer at Harvard University, has ventured that we may live in a cosmic "zoo" not to be violated by responsible advanced cultures, for whatever unknown reason. But perhaps the zoo is leaky and tidbits of information-bearing radiation are benevolently thrown our way.

Cornell's Frank Drake has suggested that aliens may be almost immortal, and thus afraid to contact "hazardous" young races on distant planets. And Paul Horowitz points out that sending signals is so much more efficient than sending spaceships that aliens might simply rather communicate than commute. But more than anything, SETI researchers maintain that our efforts to look—or listen—for aliens simply haven't been sufficient. Says Jill Tarter, research astronomer at the University of California at Berkeley, "The answer to 'Where are they?' properly ought to be 'How should we know? We haven't looked very hard yet.'"

Scanning the Cosmic Haystack

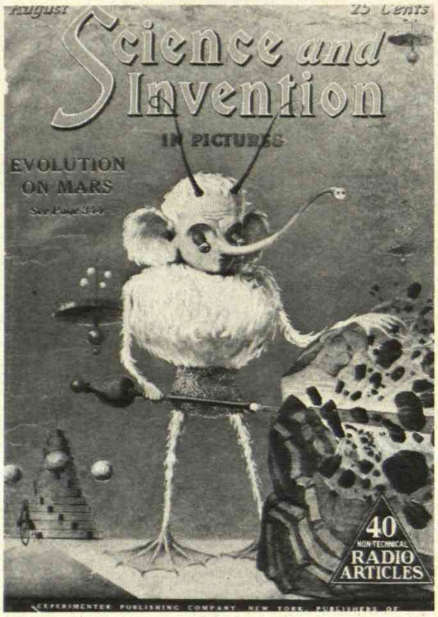
In the first realistic attempt to detect extraterrestrial signals, called Project Ozma, in 1960, Frank Drake used an 85-foot-diameter dish at the National Radio Telescope Observatory in Green Bank, W. Va., to monitor two nearby sunlike stars, Tau Ceti and Epsilon Eridani. Scientists in several nations have since made perhaps

"The searches to date have been like trying to find a needle in a haystack by walking past the haystack every now and then."

three dozen other searches. For example, Robert Dixon of Ohio State University has for more than ten years scanned the sky using a telescope the size of a football field. Researchers at the Jet Propulsion Laboratory and the University of California at Berkeley have been "sneaking" observing time using antennas usually used to track interplanetary spacecraft. The piggyback nature of the project earned it the name Serendip, also an acronym for Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations. And in the Soviet Union, V.S. Troitsky and colleagues at the Gorky Radiophysical Institute have scanned the skies since 1970 for sporadic pulses of possible intelligent origin.

Although none of these projects has yielded unambiguous evidence of alien transmission, there have been some exciting moments along the way—such as signals later found to be terrestrial interference and a curious few that did not persist long enough to be identified. Perhaps the most famous false alarm came in 1968 in England, at a radio telescope not even dedicated to SETI, when Jocelyn Bell, a Cambridge University graduate student, and Antony Hewish, her professor, detected regularly spaced pulses arriving every one and one-third seconds. It turned out that they had discovered pulsars, the long-sought neutron stars predicted by physicists. But at least for a while, Bell and Hewish referred to their signal as "LGM-1," for Little Green Men.

"The searches to date have been like trying to find a needle in a haystack by walking past the haystack every now and then," says Drake. Indeed, only a small fraction of the "cosmic haystack" has been surveyed, and there is so much territory that previous part-time and even full-time efforts would be unlikely to have borne fruit. Some of the searches targeted hundreds of specific stars in the solar neighborhood that were deemed likely to have life-bearing planets. These stars were examined extensively at many frequencies. Other searches have been "whole-sky," sweeping large areas of the heavens without focusing on specific nearby targets but monitoring a smaller part of the radio spectrum. The number of stars searched so far, says Carl Sagan, an astronomer at Cornell and well-known SETI enthusiast, constitute "only a millionth of a percent of the stars in the galaxy."



Many people once considered martians a sure bet. This creature graced a magazine cover in 1924, blasting rocks with an atomic device.

Magic Frequencies and the Water Hole

Today's radio telescopes could detect beams directed at Earth from identically sized and powered antennas located on the other side of the galaxy. (Of course, if we were to try to detect "leakage" signals from advanced civilizations that were not deliberately beamed at Earth, similar to our radio, radar, and television signals now leaking into space, antennas would need to be much larger than any now available, and costs would rise dramatically. You need big ears to detect a faint noise. For now, nothing is lost in neglecting this possibility.)

The idea of monitoring radio waves rather than other regions of the electromagnetic spectrum, such as visible light, infrared, or x-rays, traces back to 1959. Philip Morrison and Giuseppe Cocconi, physicists then at Cornell, reported in *Nature* magazine the advantages of searching radio frequencies. Specifically, they proposed that the microwave region was best suited for SETI—the frequency range between about 1 billion and 10 billion hertz, or 1 to 10 gigahertz. (A hertz is one cycle per second.)

Why microwaves? This region is a relatively quiet "window" for listening. The galaxy is a noisy place. Cosmic static includes the noise generated by fast-moving charged particles in interstellar space, as well as remnant echos of the original Big Bang of creation. Radio telescopes themselves make so-called "quantum noise," and molecules in the Earth's atmosphere absorb some incoming radiation. In all, the microwave region is where the noise is least and reception is best. Thus, an extraterrestrial transmitter beaming microwaves wouldn't have to "shout" so loud to be heard—a fact that radio astronomers everywhere in the galaxy would know. (*See chart on facing page.*)

"But that's still an enormous range of frequencies," says Harvard's Paul Horowitz. "What's needed is some universal frequency marker that would be recognized by civilizations that had not previously communicated." Morrison and Cocconi solved this problem as well, suggesting that one particular frequency within the microwave window might be a "magic frequency." This is 1.420 gigahertz, or 1420 megahertz as it's more commonly called. Radio waves of this frequency are emitted naturally by neutral hydrogen atoms, the simplest and most abundant atoms in the universe. So the physicists' notion was that 1420 megahertz might serve as a signpost or likely meeting place for galactic cultures. As an earthly example, if you are trying to meet a friend in New York City but have no idea of the meeting site, you might reasonably hover around major points of interest, such as the Empire State Building or Times Square, hoping your friend will also have that idea.

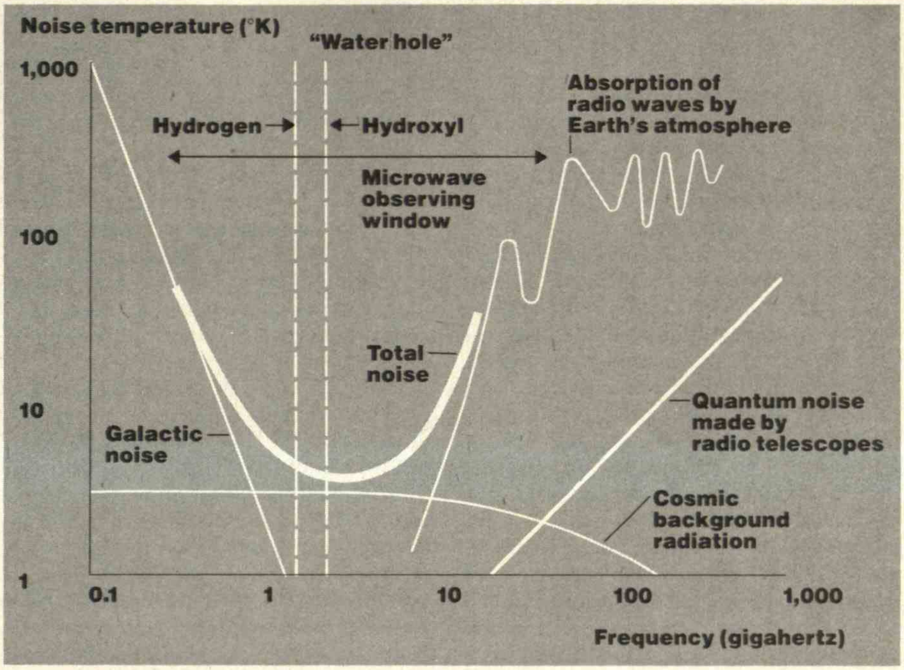
The Morrison-Cocconi proposal has withstood the test of time: radio astronomers still consider 1420 megahertz fertile ground for SETI. And researchers have also proposed other "magic frequencies." For example, hydroxyl, a molecule composed of one atom of hydrogen and one atom of oxygen, emits at about 1666 megahertz, just up the radio spectrum from neutral hydrogen. Since hydrogen and hydroxyl are the products of the decomposition of water, the frequencies between those they emit have been dubbed the "water hole." SETI researchers suggest that galactic species might mingle in this region via radio waves just as animals seek water holes on Earth.

Project Sentinel accomplishes more in one minute than would have been done in 1,000 years with the equipment used in the first SETI project in 1960.

Suitcase SETI

Paul Horowitz's Project Sentinel listens at the water hole using an 84-foot-diameter radio telescope located in Harvard, Mass. On March 7, 1983, numerous prominent figures in the SETI community ceremoniously launched the search by annointing the telescope with champagne. (The instrument had been rescued at the eleventh hour from permanent deactivation.) The key to the project is its advanced receiving system—a computerized spectral analyzer that handles signal processing and identification. The analyzer scans more than 131,000 radio channels at once, a tremendous increase over other receivers. "It is precisely because of this advance in technology," says Carl Sagan, "that SETI seems so practical and inevitable."

Horowitz developed the system, dubbed "Suitcase SETI" because of its small size and portability, while on sabbatical at Stanford University in 1981. Colleagues at Stanford and the University of California at Berkeley, computer scientist David Brainard of Harvard, and M.I.T. engineer John Forster also contributed. Horowitz tested Suitcase SETI in May 1982 at the giant 1,000-foot-diameter radio telescope at Arecibo, Puerto Rico. "That experiment, in which we spent 75 telescope hours looking at 250 nearby stars similar to our sun, constituted the world's most sensitive (though not the most comprehensive) search for extraterrestrial signals thus far," he says.



Astronomers favor the microwave region of the electromagnetic spectrum to listen for alien radio signals. Here, background noise (measured in degrees Kelvin, the temperature above absolute zero) is least and reception is best. This "window" also contains frequencies that aliens might logically choose for communications.

One is the frequency emitted naturally by hydrogen, the most abundant atom in the universe. Another is the frequency emitted by hydroxyl, composed of one atom of hydrogen and one of oxygen. Since these are the decomposition products of water, the frequencies in between, from roughly 1.4 to 1.7 gigahertz, are called the "water hole." Just as animals seek water holes on Earth, galactic species might mingle in this region via radio waves.

The current listening effort is a "whole-sky" search rather than one focused on specific stars. It assumes that extraterrestrials trying to communicate will beam their radio signals in our direction. The receiver homes in on a narrow frequency band—only 2,000 hertz wide—centered for now on the venerable 1420-megahertz frequency of hydrogen. The computer then breaks that signal into 131,072 channels, each only three-hundredths of a hertz wide, and simultaneously examines all the channels for anything unusual.

The researchers look for such a narrow signal because ordinary astronomical phenomena aren't so sharp—their emissions cover many more frequencies. Scientists have calculated that radio waves will be distorted by only one-hundredth of a hertz over a distance of 300 light-years, so aliens could transmit very narrow band signals and expect them to be clear at large distances. Indeed, the "heralding" or attention-getting part of an alien transmission is likely to be narrow, both for energy economy and to raise suspicions about the signal's artificial character.

Suitcase SETI also avoids false alarms caused by earthly radio interference, the gremlin and time waster of many past efforts. Researchers have programmed the receiver to adjust continuously for a shift in incoming signal frequency caused by the Earth's rotation and its movement around the sun—the so-called Doppler shift. The expectation is that if aliens wanted to beam a message toward our sun at a "magic" frequency and have it be the same frequency at Earth, they would adjust for the frequency shift caused by their relative motion toward the sun, which they could readily determine by spectral analysis of the sun's light. The aliens would presume us wise-enough searchers to remove the additional frequency shift that results from the Earth's motion, which they would be unable to determine. Thus, human-made interference is smeared over a large number of the narrow channels as the receiver shifts in frequency and would not register as a distinct sharp signal.

Coverage Up, Cost Down

Each day, a member of Horowitz's staff points the telescope at one celestial latitude, and the Earth's rotation causes the telescope to sweep a moon-sized path completely around the sky. The next day the telescope is shifted half a degree in latitude. Thus, it scans the latitudes from 45 degrees south of the celestial equator to

> If undisputable radio signals do arrive from space, we will have reached a dramatic turning point in the history of the human species.

60 degrees north—about 90 percent of the visible sky—in about 210 days. Another "magic" frequency can then be chosen and similarly scanned.

Suitcase SETI collects and temporarily stores 30 seconds of incoming signals. It then looks for and records the most outstanding signals while another 30 seconds of signals are being gathered. No observing time is lost. An operator usually scans the data each day for any unusual features that the computer has selected. This is done at the telescope operations building; soon, operators will be able to call up the data on remote terminals by dialing the SETI terminal on the phone. The only thing not fully automated is the daily change in the telescope's celestial latitude setting.

If interesting signals are detected, the telescope can be repositioned when the target is again visible and a special "tracking" program will examine the suspected source in detail. A persisting narrowband signal would raise great suspicions, and the world radio astronomical community could then examine its characteristics intensively. For example, a narrow herald signal might "point" to a broader band in the spectrum having more complex form, a signal normally hidden in the background noise.

Though far ahead of other searches, Project Sentinel is already being improved. Researchers are modifying the analyzer so that it collects a wider band of frequencies and examines many more channels. Specifically, the analyzer will handle a 350,000-hertz bandwidth, compared with the current 2,000-hertz capacity. And it will break the incoming signals into 8.4 million channels that are examined simultaneously. "It will be the equivalent of listening with 8.4 million receivers at once," says Horowitz. Expanding the system will cost less than $100,000—a relatively modest cost made possible by advances in microcircuit technology that have brought chip prices down threefold since Suitcase SETI was built in 1981. When the system is completed, perhaps by mid-1984, it will surpass all previous SETI projects combined in the first 30 minutes of operation.

The new system has been given its own name, META, for megachannel extraterrestrial assay. One of META's advantages is that it will be able to detect transmissions that are not beamed directly at the Earth, as the present system assumes. Instead, aliens can transmit powerful omnidirectional beams without worrying about correcting for frequency shifts caused by relative star motions. The analyzer's expanded bandwidth capacity is large enough to "catch" a beam even if it has drifted off the original magic frequency.

And there is more. Philip Morrison of M.I.T., who catalyzed SETI research more than two decades ago, recently pointed out that META's expanded frequency coverage will let the system take advantage of the so-called "cosmic rest-frame." Details are complex. All around us in distant extragalactic space is a "glow" of radiation left over from the Big Bang of creation, and this radiation is uniform in all directions. "This is a 'fixed platform' that we cannot ever visit," says Morrison. "But by analyzing that glow, we can—as any astronomer anywhere can—determine our own motion relative to that platform."

So what aliens might reasonably do is to transmit many beams at 1420 megahertz, the magic frequency of hydrogen, but shift each beam they send to the frequency it would have if it were in the cosmic rest-frame. Thus, each sender and receiver is always able to correct for "his" own motion. This, he says, would be "the most magic of magic frequencies," since every advanced civilization would certainly recognize it. The new META analyzer can handle a frequency bandwidth large enough to allow for our present error in determining this universal standard of rest. "The scheme promises a meeting place in not too wide a range on the radio dial that can include every would-be communicator within our Local Group of galaxies," says Morrison. "However, galaxies that are really far away still raise problems."

The Search Goes On

What are the chances of success of the SETI projects? "You don't do something like this and think you're going to detect a signal next week," says Horowitz. "Our chances of picking up a signal may be small. But if we don't try, they're zero." SETI optimists, buoyed by the prospect of persistent searches using the latest technology, feel that alien signals could be detected within the next 50 years. If signals do arrive, Carl Sagan believes a "dramatic turning point in the history of the human species will have been reached."

If current efforts to listen in the microwave region of the spectrum do not produce results, it will be time to expand the search to other portions of the electromagnetic spectrum. Scientists can also begin planning larger, more sensitive antennas and perhaps look for faint optical evidence of distant planetary cultures. For example, Princeton University physicist Freeman Dyson has suggested that cultures may have surrounded their parent star with energy-collecting structures that emit infrared signatures. Other scientists have proposed that advanced societies might deliberately seed their star with radioactive elements whose spectra would be evidence of technology. There are also those who think beyond merely searching from Earth for messages—suggesting that it may be possible to send advanced robot spacecraft and, someday, even manned "space arks" out into the galaxy. (*See "Starflight: The Ultimate Voyage," page 60.*)

However, the microwave search itself will not have been wasted even if no evidence of aliens is found. The search will yield new tools for radio astronomy, and it is almost a rule in the history of astronomy that new observational techniques have led to new discoveries. The high-speed information-handling technologies being developed for the search may also find application elsewhere.

Of course, SETI researchers are hopeful that extraterrestrials will indeed "phone Earth," and they believe the cost of searching is within reason. "The cost of all SETI programs up to now, by all nations, is less than the cost of a single military attack helicopter," says Sagan. "The cost of a major search program with state-of-the-art technology and existing radio telescopes, continuing over 10 or 20 years, is perhaps one-third the price of a B-1 bomber." Others liken the cost to 15 minutes of tobacco use in the United States. This seems not an unreasonable expenditure for experiments that at best might revolutionize human culture, and at least serve as a reminder of our continued quest to know our place in the cosmos.

EUGENE F. MALLOVE, an astronautical engineer at M.I.T.'s Lincoln Laboratory, has assisted Project Sentinel. He received an S.B. and S.M. in aeronautical and astronautical engineering from M.I.T., and an Sc.D. from the Harvard School of Public Health.

NASA's new SETI program, born again after years of neglect, will employ the world's largest radio telescope. Here, a worker wears special pads on his feet to protect the 1,000-foot-wide dish at Arecibo, Puerto Rico. Researchers are now building the "next generation" of spectral analyzers and other instruments for NASA's search. They will do some listening as the equipment is tested, but major searches will begin in 1988—by far the largest SETI program ever. Smaller radio telescopes in NASA's Deep Space Network will be used to make "whole-sky" surveys. Arecibo and other large telescopes will be focused on several hundred stars that are especially promising. (Photographs: Cornell University)

NASA's SETI: Bigger Is Better

BY J. KELLY BEATTY

HISTORIANS of science will someday recall the 1980s as the years when the astronomical community "came out of the closet" in support of SETI, the search for extraterrestrial intelligence. Once the sole province of a few maverick professionals, SETI now enjoys unprecedented respectibility—a position buoyed by increased funding from NASA as well as private organizations, approving nods from various study groups, and the overt support of hundreds of astronomers worldwide.

Yet even the most ardent proponents of SETI concede that a truly thorough search for the radio beacons of extraterrestrial civilizations would be overwhelming in both time and resources. Complete coverage would require listening carefully at all radio frequencies, in all directions, all the time—far beyond current technological means. For example, even a massive program linking the world's entire inventory of large radio telescopes could not hope to cover more than a tiny fraction of the sky at any given moment. And there is significant resistance to using the giant dishes at all for SETI work.

Moreover, any incoming signals would probably be packaged into narrow frequency bands, permitting them to propagate most efficiently across interstellar space. This forces astronomers either to guess the most likely transmission frequencies, as Harvard's Paul Horowitz does in Project Sentinel, or to scan ever-larger swaths of the radio spectrum in finely divided segments. Fortunately, recent advances in solid-state electronics have made simultaneous searches of millions of discrete frequencies not just possible but relatively inexpensive.

Warmer Climate

The very involvement of NASA demonstrates how favorable the political and scientific climate has become for SETI. NASA's participation has been on-again, off-again over the past decade. For example, in 1977 a blue-ribbon scientific panel recommended that "it is both timely and feasible to begin a serious search for extraterrestrial intelligence," and NASA took steps toward establishing such a program. But the following year Senator William Proxmire awarded the agency one of his "Golden Fleece" awards and persuaded Congress to terminate SETI funding.

The urgings of many scientists, most notably astronomer Carl Sagan of Cornell University, gradually softened opposition to NASA's participation—Proxmire's position is now one of "skeptical neutrality"—and in October 1982 the agency took up SETI work anew. "Our objective," says John Wolfe of NASA's Ames Research Laboratory, "is to figure out how to do SETI economically."

Over the next five years NASA plans to create the electronics and logistics for a search so extensive that, according to Horowitz, "it will blow the rest of us out of the water." However, NASA officials are careful not to label the $10 million project more than an exercise in "research and development," since Congress has not yet given the go-ahead for a full-scale search.

Since October, the NASA program has been directed by Bernard M. Oliver, who recently retired from an executive position at Hewlett-Packard. Oliver is no newcomer to the SETI scene; in 1972 he proposed "Project Cyclops," a vast network of radio telescopes that would carry out a dedicated search for alien signals. The Ames Research Laboratory and the Jet Propulsion Laboratory share responsibility for developing NASA's system. These two field centers have been noted for their outright competition within NASA, but on SETI they show singleness of purpose. The alliance takes advantage of JPL's worldwide network of radio dishes normally used for tracking spacecraft and Ames's experience in formulating extraterrestrial search strategies.

Taking a Bigger Bite

At the heart of the NASA concept is a sophisticated spectral analyzer being developed at Stanford University by Allen Peterson and Kok Chen. The analyzer will monitor a larger segment of the radio spectrum, and do so more thoroughly, than any existing instruments.

Specifically, the analyzer will take an 8-megahertz (or 8 million hertz) bite out of the spectrum. By comparison, the analyzer used in Project Sentinel, by far the most sophisticated operating today, covers a bandwidth of only 2,000 hertz, and the improved version being developed will handle a bandwidth of about 350,000 hertz. NASA's analyzer will break the incoming signal into 8 million channels, each 1 hertz wide, and analyze them simultaneously. At the same time, it will also examine larger groups or "bins" of frequencies in the signal, allowing scientists to detect alien transmissions that are broader and might not be obvious in the 1-hertz channels.

The researchers tested a prototype analyzer that dis-

sects signals into a modest 74,000 channels at Stanford in late October. This spring, they will attach the device to large radio telescopes as a "compatibility check," says deputy project scientist Sam Gulkis. This will be followed by construction of one or more of the proposed 8-megahertz units. But other instruments to handle the analyzer's awesome output—more than 1 billion bits of encoded data per second—have yet to be designed. Once integrated with the analyzer, these signal processors will automatically sift through the stream of data in search of patterns that warrant inspection. For now, the output will be processed with a conventional computer.

Listening at the Window

Armed with a megachannel analyzer, NASA scientists hope to begin a two-part search of unprecedented magnitude in 1988. In one phase they will employ the antennas in JPL's Deep Space Network—located in California, Spain, and Australia—for a sweep of the entire sky at 1 to 10 billion hertz (1 to 10 gigahertz), with some additional coverage between 10 and 25 gigahertz. "This is essentially the entire microwave window available to us for observing," notes Gulkis, a range that includes what scientists believe to be the most likely frequencies for interstellar communication. Even with its 8-million-channel appetite, the NASA package will require roughly three years to complete its all-sky search using JPL's moderate-sized antennas. And since the antennas won't linger on a given location as they rapidly scan the heavens, only strong signals will be detectable.

In the second phase the analyzer will be attached to ultrasensitive radio telescopes such as the gigantic 1,000-foot-diameter dish at Arecibo, Puerto Rico, to study individual stars. The stars will be scrutinized from 1.2 to 3 gigahertz for both continuous-wave, or carrier, signals and higher-energy pulsed transmissions. This portion of the radio spectrum contains certain frequencies of universal importance to radio astronomy, making them logical choices for interstellar transmissions. Topping the list of candidates for this "stop and stare" search are the 773 stars most like the sun within a radius of 80 light-years (475 trillion miles). The assumption is that such stars are the most likely to have planets and, perhaps, advanced life forms.

Because of its stationary construction, the Arecibo antenna can observe only about 200 of the solar-type stars. Other world-class radio telescopes may be called upon to complete the list, or the scientists can simply use the smaller JPL antennas to monitor the remaining targets for long periods of time. NASA would prefer to use the largest-possible antennas; they not only record the faintest signals but can also pinpoint the location of sources with great accuracy.

Signals vs. Interference

One major problem with the search program is likely to be radio-frequency interference (RFI) from human sources such as radar and communication systems, even though many frequencies in this spectral region are designated solely for astronomical use by international agreement. Classified military radio transmissions are also expected to be among the proposed search frequencies, which only adds to the potential for confusion and false alarms. "When you try to assess the potential effects of RFI," admits Gulkis, "the first thing you learn is that there's almost nothing known about it."

Yet the whole thrust of NASA's plan is to conduct SETI with automated equipment, so ultimately the scientists will have to teach their machine how to discriminate between radio chatter and the real thing. Ironically, the very process of rejecting unwanted noise may eliminate genuine signals too weak to pass an electronic "screen test."

But proponents of SETI are happy to see NASA's effort underway, since radio interference should only worsen in the years ahead. And though the NASA program will be limited to seeking broadcasts that aliens actually intend to be detected, it could well establish the basis for more ambitious future undertakings. Project Cyclops, for example, would be sensitive enough to eavesdrop on aliens' inadvertent transmissions—just as earthly radio beams could be picked up as they race out into space at the speed of light. Or we may eventually choose to build automated listening posts placed away from Earth's radio noise, perhaps on the far side of the moon.

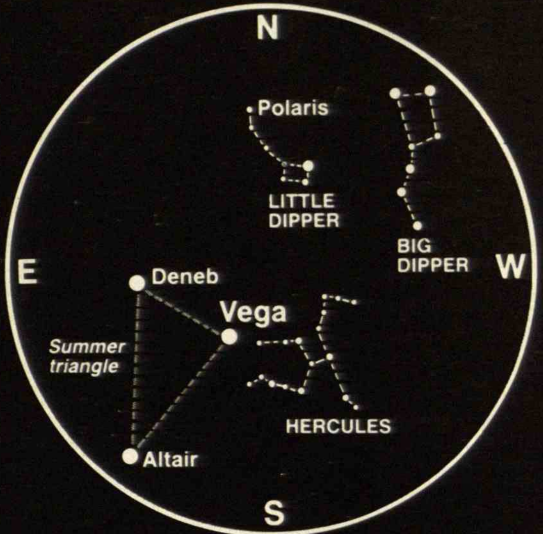
For the present, however, NASA is content with its infant program, especially considering how much skepticism remains concerning SETI's worth. Carl Sagan, for one, finds the situation promising. "It's clear that no amount of philosophical ruminations will decide this issue," he says. "One can imagine that contact with other beings will happen accidentally, but it's really better to try to find them." □

J. KELLY BEATTY is senior editor of Sky & Telescope *magazine.*

PHOTO: PETER MENZEL

PHOTO: DENNIS DI CICCO, SKY & TELESCOPE; INSETS:

Prospecting for Planets



The Infrared Astronomical Satellite recently added support to SETI. IRAS, which detects heat rather than light, revealed a cloud of solid material around the star Vega that may be forming into planets. IRAS has now spotted several dozen stars ringed with warm material—the best evidence yet that many stars may have planets, which in turn may support alien civilizations. IRAS also revealed that vast clouds of dust and gas, such as the Orion Nebula, are spawning stars like our sun faster than suspected. Above: IRAS and a view of Vega's location in the summer sky. Opposite: The Milky Way, with Vega the brightest star just to the right of the galactic disk. Insets: NASA's concept of Vega's cloud, and an image of the sky around Orion made from IRAS data.

SEARCHING for alien life would be easier if astronomers had a more specific idea of where to look. They assume, of course, that extraterrestrials inhabit the unseen worlds of distant suns, but which of the billions of stars in our galaxy should get special attention? Can one choose among even the few thousand stars that are relatively close by?

Now, thanks in part to the recent findings of a revolutionary satellite, astronomers are getting a better feel for where to point their SETI radio antennas. The new satellite has not actually spotted "extrasolar" worlds, but it clearly shows that many stars are in the process of forming them. Warm dust and gas surrounding a newborn sun, which may eventually coalesce into planets, should glow with thermal infrared radiation. Unfortunately, our atmosphere absorbs almost all infrared radiation before it reaches the ground.

Enter the Infrared Astronomical Satellite (IRAS), an international venture launched in early 1983 to give astronomers their first complete view of the infrared sky. Circling 560 miles above the Earth, its cryogenically cooled instruments peered into space with unprecedented sensitivity. However, because of the satellite's technological complexity, project scientists were initially very cautious about interpreting their bountiful findings. Indeed, outside astronomers found themselves uncharacteristically isolated from the data.

Then, five months into the mission, a surprising revelation leaked out: Vega, a bright, relatively young star, is apparently surrounded by an extensive cloud of material that is buckshot-size and larger. "Vega may represent an intermediate stage in the development of planetary systems," says IRAS scientist Fred Gillett. The material is not particularly warm (about −300°F) but astronomers are amazed that it's there at all.

More important to the SETI forces is the fact that Vega is not unique. At a NASA press conference in November, Gillett announced that IRAS had detected several dozen other stars encircled by warm material. Project scientist Charles Beichman offered equally encouraging news: within far-flung interstellar clouds of gas and dust, such as the Orion nebula, stars like our sun are being created more frequently than previously thought—at the rate of about one per year. If even a small fraction of these have evolved planets as well, some of those worlds must experience Earthlike temperatures and, perhaps, possess other assets conducive to life.

Attempts to locate other solar systems have been underway for decades, but the enormous void separating us from even the nearest stars makes planetary detection impossible, visually or photographically, with any existing telescope. Astronomers can infer the existence of planets by noting subtle effects they exert on their central suns, and a growing number of neighboring stars are the suspected hosts of gas balls the size of Jupiter. But conclusive proof is not yet in hand, and smaller planets more like the Earth would be even harder to detect.

To actually pick out individual planets will require telescopes well beyond the capabilities of IRAS, which ran out of cryogenic power in November. Jupiter-size worlds may be observable with NASA's Hubble Space Telescope, an orbiting observatory scheduled for launch in mid-1986. And early next decade, new spaceborne infrared telescopes may detect warm, discrete blips around nearby stars.

Of course, SETI researchers needn't hold their collective breath in anticipation of these missions. In fact, they would really prefer to hear an extraterrestrial's radio signals before other astronomers spot its home.
—*J. Kelly Beatty* □

CHART: NEWSWEEK; PHOTO: NASA

Starflight: The Ultimate Voyage

THE next horizon has always challenged human beings, and the interstellar gulf is no exception. Many SETI advocates maintain that starflight is best left "on the back of the cereal box." But hundreds of scientists, engineers, and inventors think otherwise.

Indeed, this starflight community actively probes the question of how such voyages will be made. For example, the *Journal of the British Interplanetary Society* regularly contains detailed engineering discussions of interstellar travel. Would-be galactic sailors have identified a number of possible propulsion technologies, projected optimal trajectories to various stars, and discussed every manner of navigation subsystems and scientific payloads.

What, short of actual interstellar journeys, could quench this pioneering thirst?

Robot Ships First

The central difficulty, of course, is the vastness of the distances to be traversed. The nearest destination, Proxima Centauri, is more than 250,000 times farther from Earth than is the sun—a journey of 4.3 years as light flies. Today's chemically propelled spacecraft, or even nuclear rockets that might soon be possible, would take tens of thousands of years to get there.

Thus, robot probes will probably be the first interstellar emissaries. (In fact, a probe is already underway—the U.S. *Pioneer 10* spacecraft crossed the outer bounds of the solar system in July 1983 while still sending back information.) In 1977, the Jet Propulsion Laboratory released its *Interstellar Precursor Mission Study* of a probe that could be launched by the year 2000. The 50-year scientific mission would explore interstellar space out to 1,000 times the distance from Earth to the sun. Making equipment reliable enough for such a mission would strain the limits of today's technology and require development of such items as computers that test and repair themselves.

Early interstellar missions will probably use refined versions of propulsion systems now being developed. One possibility is the "ion-drive" engine. This engine would use electricity generated by a nuclear reactor to transform a propellant into charged particles—ions—which would then be accelerated by an electric field and rapidly expelled to provide thrust. NASA has already tested in space prototype ion-drive engines made by Hughes Aircraft Co., and in 1985 the air force plans to launch a satellite that will use such engines to provide maneuvering.

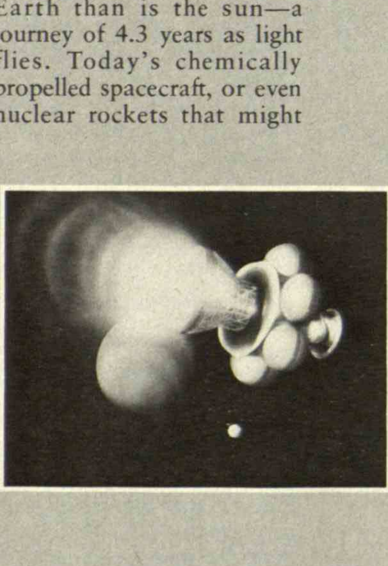
More ambitious probes driven by advanced propulsion systems might depart by the middle of the next century. For example, in the mid-1970s the British Interplanetary Society conducted perhaps the most detailed feasibility study of an interstellar trip. In the society's scenario, a starship, named *Daedalus* after the legendary inventor in Greek mythology, would make a flyby mission to Barnard's star located nearly 6 light-years away. *Daedalus* would be propelled by thermonuclear "microexplosions" ignited 250 times a second by laser or electron beams. The ship would accelerate to about 12 percent the speed of light—some 36,000 kilometers per second, or more than 1,000 times faster than today's rockets. The one-way trip is scheduled to take 50 years.

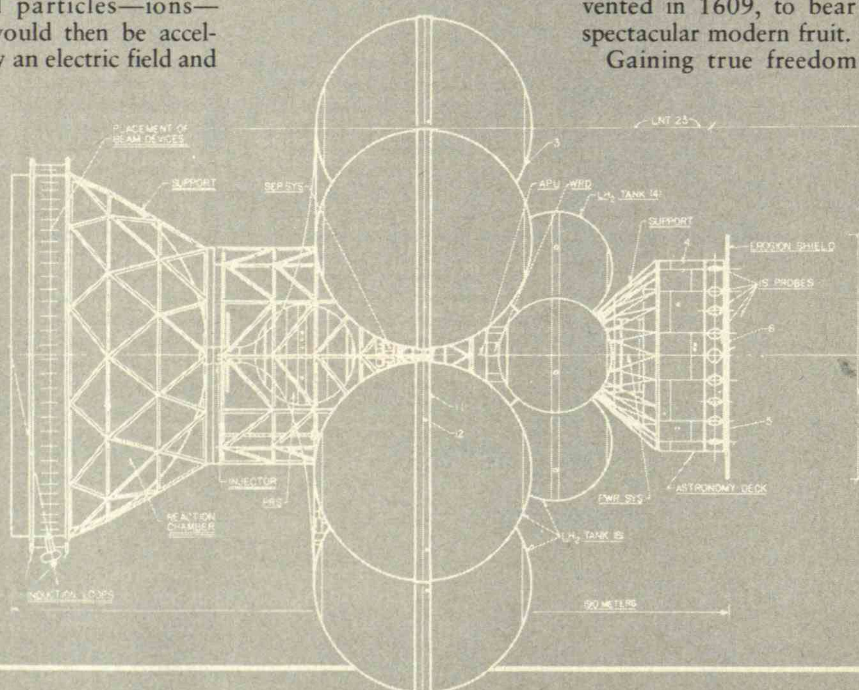
Space Sailing

"Light sails" are another possibility for starships of the twenty-first century. Manufactured in space, the sails will be made of thin metallic film and will be hundreds of miles across. They will tow payloads tethered to the sail by thin, ultrastrong cables. Some of the sails will be propelled by radiation from the sun—or, someday, by radiation from other stars. Other sails may be pushed out of the solar system by powerful lasers stationed in orbit around the sun.

Gregory Matloff of Pratt Institute and I have determined that a sail can be blown out of the solar system at more than 1 percent the speed of light after passing relatively close to the sun. Thus, small robot probes towed by light sails might reach Proxima Centauri in only 350 years. Astronomers waited nearly that long for the optical telescope, invented in 1609, to bear its spectacular modern fruit.

Gaining true freedom in





the cosmos may require leaps of science and technology almost beyond our imagining. But glimmerings may already be seen. For example, there is the "interstellar ramjet" proposed by Robert Bussard, president of INESCO, which conducts research on fusion power. This mile-long ship will generate a huge magnetic field to collect interstellar hydrogen to burn in its fusion engines. According to plans, the craft will collect fuel faster as it speeds up, which in turn makes the ramjet work even better.

Robert L. Forward of Hughes Research Laboratories and others have investigated the production, storage, and use of antimatter for rocket propulsion. In such an engine, matter and antimatter would come together and instantly annihilate each other, creating a flash of energy. One of the most promising rockets would use protons and antiprotons; the energetic particles generated during annihilation would be mixed with large quantities of hydrogen and funneled through a "magnetic nozzle" to create thrust. The antimatter rockets common in science fiction may be distant, but their lower-performance cousins might well be used in the next century.

Interstellar Arks

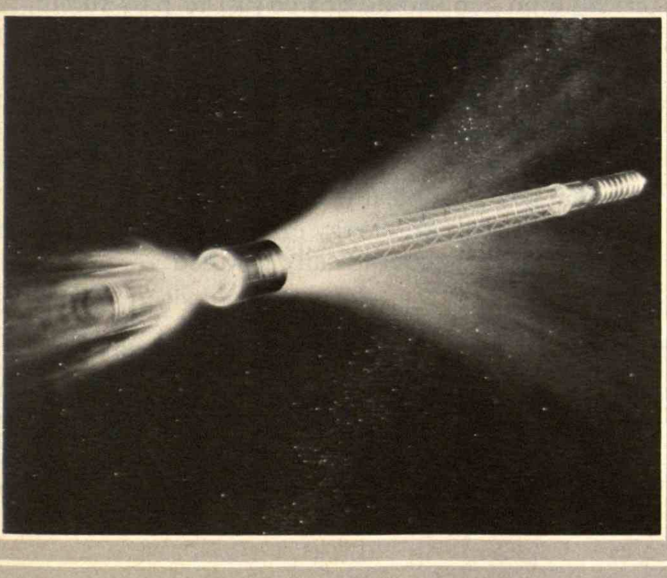
The question of human travel is always the centerpiece of starflight speculation. Some enthusiasts have analyzed the effects of the interstellar medium on vehicles moving at nearly the speed of light. The possibility of traveling at "relativistic velocities" is intriguing because of the practical benefits of special relativity's "time dilation." This well-known effect, described by Albert Einstein, would make flights of almost any distance possible within an astronaut's lifetime if—a mighty big if!—speeds over 99 percent that of light can be reached.

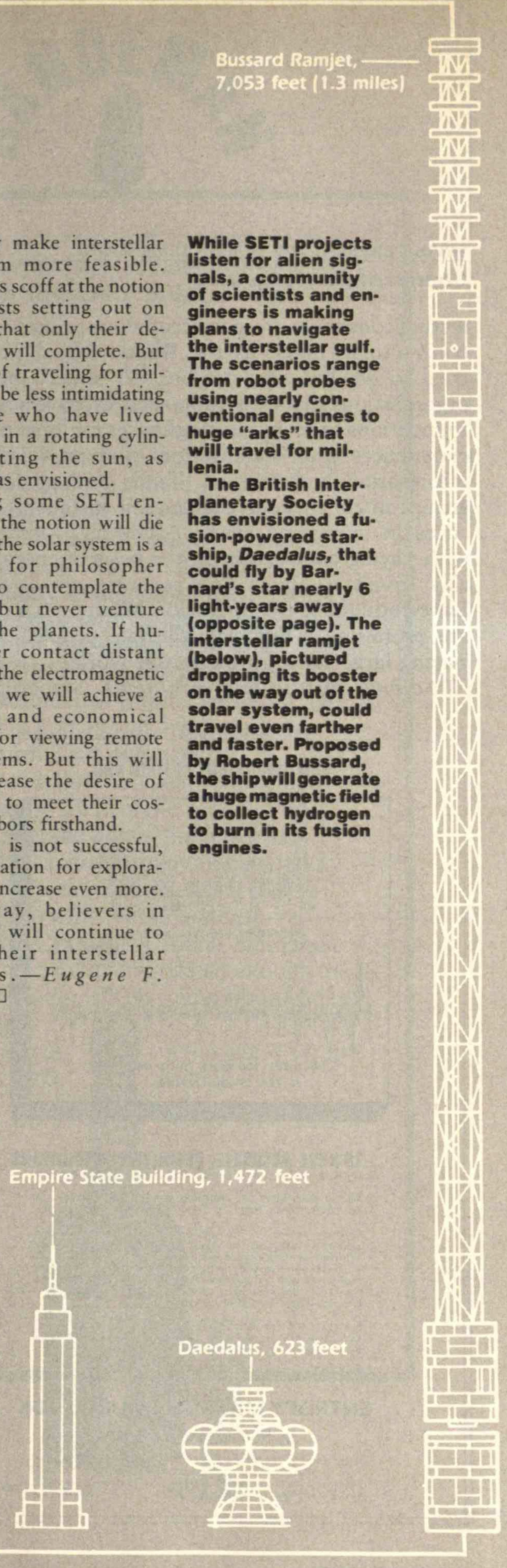
But if humans can't ever travel that fast, they might instead travel in multigenerational "interstellar arks." As early as 1929, British crystallographer John Desmond Bernal envisioned space colonies journeying through the galaxy in starships, or even in hollowed-out asteroids.

Today, the designs for space colonies promoted by Gerard O'Neill of Princeton University make interstellar arks seem more feasible. Nay-sayers scoff at the notion of colonists setting out on journeys that only their descendants will complete. But the idea of traveling for millenia may be less intimidating to people who have lived their lives in a rotating cylinder orbiting the sun, as O'Neill has envisioned.

Among some SETI enthusiasts, the notion will die hard that the solar system is a province for philosopher kings who contemplate the universe but never venture beyond the planets. If humans ever contact distant races via the electromagnetic spectrum, we will achieve a precious and economical window for viewing remote star systems. But this will only increase the desire of earthlings to meet their cosmic neighbors firsthand.

If SETI is not successful, the motivation for exploration will increase even more. Either way, believers in starflight will continue to dream their interstellar schemes.—*Eugene F. Mallove* □





While SETI projects listen for alien signals, a community of scientists and engineers is making plans to navigate the interstellar gulf. The scenarios range from robot probes using nearly conventional engines to huge "arks" that will travel for millenia.

The British Interplanetary Society has envisioned a fusion-powered starship, *Daedalus*, that could fly by Barnard's star nearly 6 light-years away (opposite page). The interstellar ramjet (below), pictured dropping its booster on the way out of the solar system, could travel even farther and faster. Proposed by Robert Bussard, the ship will generate a huge magnetic field to collect hydrogen to burn in its fusion engines.

DRAWINGS: RICK STERNBACH, COURTESY OF SCIENCE DIGEST

Continued from page 25

tecting consumers from unscrupulous or incompetent contractors—much as the Rhode Island program tried to do, but on a far broader scale. Consumer organizations might be supported by government or foundations to act as clearinghouses for local people's experiences with organizations that provide energy information and services. Trade and professional groups might make available their members' experiences in improving energy efficiency. Experiments with paying contractors on the basis of energy actually saved, such as one recently conducted in Lakewood, N.J., by the Mellon Institute of Research, are promising. They may alleviate people's fear of paying large sums for ineffective work.

□ *Solving institutional problems.* Sometimes no single person or organization is in the position to take decisive action to save energy. This problem may be worst in rented buildings. But experienced negotiators might help owners and occupants overcome their conflicting interests and agree to share the expense—and the benefits—of conservation. For such arrangements to become widespread, credible local organizations should become involved—developing model agreements, adapting them to particular situations, and spreading the word of how they work.

Social Policy

Of course, energy-saving technology must continue to be improved, and true economic barriers to energy efficiency must be faced. A government seriously supportive of energy efficiency must make it easier for low-income people and struggling small businesses to invest in conservation. But despite their economic and technological aspects, energy programs can succeed only if people participate. Energy policy is, in part, social policy.

The human side of energy policy is as much in need of attention—indeed, of research and development—as are new technologies. Government would not consider allowing a new drug to be sold, and industry would not consider introducing a new automotive technology, without careful pilot studies. By the same logic, conservation programs should be evaluated on the basis of their effectiveness in realistic field trials, rather than being designed from theoretical or intuitive assumptions. The purpose of this empirical approach should not be just to pass summary judgment about the effectiveness of an innovation but to modify and improve it.

Only a national effort to conserve energy based on a firm understanding of individual and social behavior can mobilize the energy of people to support common goals. Ironically, if government policies rely on economics alone, energy efficiency will remain far short of what is economically justified.

PAUL C. STERN is study director for the Committee on Behavioral and Social Aspects of Energy Consumption and Production of the National Research Council. He heads the energy committee of the Division of Population and Environmental Psychology of the American Psychological Association, and is coauthor of Home Energy Conservation: Programs and Strategies for the 1980s.

Continued from page 4
to be about five years for present fusion reactor designs. There are promising concepts for changing the first wall without excessive down time, including modular designs and advanced robotics. Moreover, substantially longer first-wall life may be possible with advances in materials technology and improved designs.

Although fusion reactors will be complex, new technology will undoubtedly improve the reliability of such complex systems significantly over the next few decades. Present civilian aircraft are far more complex than aircraft of 40 years ago but are also more reliable.

Range of Reactor Design Features

Lidsky continually downplays the wide range of possible fusion reactor design features and emphasizes the least attractive possibilities. He mentions that the liquid lithium used in the tritium breeding blanket "reacts explosively with air and water." However, he does not discuss alternatives such as lithium compounds, eutectics, and molten salts that do not have the potential for explosion. Nor does he mention the possibility that constraints on blanket design could be reduced by the use of tritium-lean deuterium-tritium fuel mixtures with a decreased tritium breeding requirement, or by the use of pure deuterium fuel that does not require any tritium breeding.

The magnet technology and plasma size requirements need not be as limited as Lidsky implies. He states that superconducting magnets, cooled by liquid helium to temperatures near absolute zero, must be used. However, some reactor concepts utilize water-cooled copper magnets. And Lidsky comments, "The best theories available suggest the radius of the plasma must be at least two to three meters if the fusion reactor is to be self sustaining." Yet theoretical models do predict ignition in some tokamak devices with a plasma radius of less than one meter.

Nonelectric Applications

Lidsky fails to discuss the potential nonelectric applications of neutron-producing fusion reactors, which could be very useful. One possibility is producing synthetic fuel using the very high coolant temperatures that may be possible in
Continued on page 79

An Old Cancer Therapy with New Promise

More than 20 years ago, a group of physicians and nuclear engineers tried a radical new therapy on patients with malignant brain tumors. They injected a chemical compound containing boron into the arteries that carry blood to the brain. Then, using a nuclear reactor, they shot slow neutrons into the patients' brains. They hoped that when the neutrons struck the boron, enough radiation would be created to destroy the tumor cells.

The experiment was a disaster. All 17 patients died within months after treatment, bringing similar research efforts to a screeching halt. The vast majority of neurosurgeons in the United States lost all interest in "neutron-capture therapy" as a treatment for cancer.

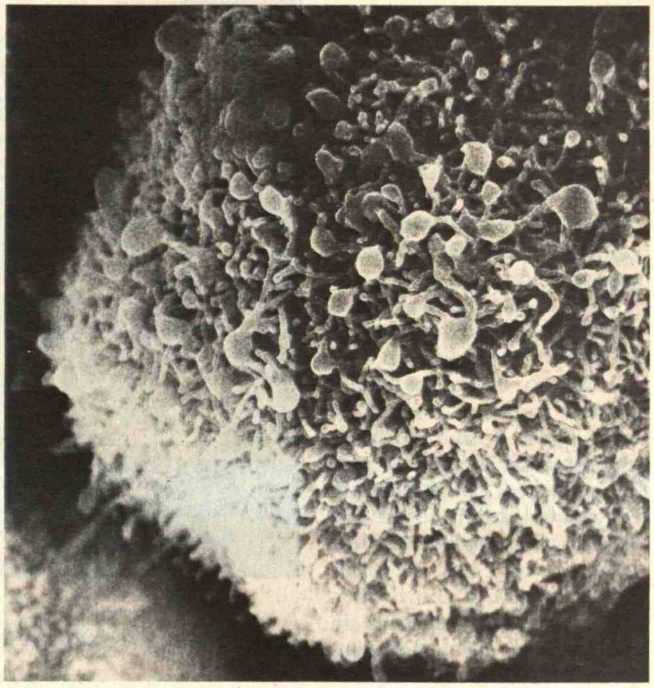
But they didn't in Japan. One Japanese neurosurgeon, who had been involved with the study at Massachusetts General Hospital (MGH) and M.I.T., returned to his native country and continued to work with neutron-capture therapy there. Dr. Hiroshi Hatanaka eventually came up with a modified regimen for the therapy and achieved a 33 percent survival rate in patients with a type of brain cancer that is almost always fatal.

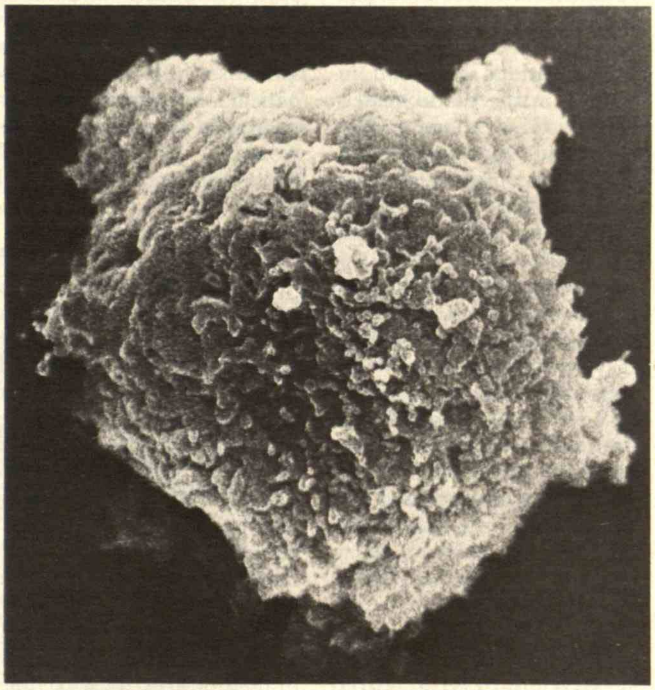
Hatanaka announced his highly successful results at an M.I.T. conference last fall. And that was not all he announced. His results, he told the crowd, meant that the experiment done in Boston in the early 1960s and a smaller trial at Brookhaven National Laboratory in the 1950s were "not really failures. They were merely a reflection of our limited knowledge 20 years ago." For the pioneers of both studies, those were sweet words indeed. "We are very pleased with Hatanaka's results," said Gordon Brownell, professor of nuclear engineering at M.I.T. and a participant in the M.I.T./MGH study. "In a nice symbolic way, his work is a continuation of what we did."

Mini-Nuclear Explosions

Physicists had discussed the possiblity of applying the neutron-capture phenomenon to cancer treatment as far back as the 1930s. They knew then that the "capturing" or absorption of neutrons by boron in human tissue created mini nuclear explosions that produced enough radiation to destroy cells in a specific area. In the 1950s, William Sweet, a neurosurgeon at MGH, noticed that boron, being an inorganic substance, cannot easily cross the blood-brain barrier that protects normal cell tissue in the brain. But the same compound easily penetrates tumors, which are usually so "hungry" that they will devour anything. The quest in cancer therapy has always been to find a weapon that would destroy tumorous tissue without killing normal tissue as well. So the propensity of boron to settle in tumor cells was considered highly attractive.

Glioblastomas are an especially difficult type of brain tumor to treat because they invade normal tissue, becoming entangled in a skein of shared blood vessels and proteins. Conventional treatments such as chemo-





In neutron-capture therapy, boron compounds injected into the blood are absorbed by tumor cells in the brain. These cells are destroyed when neutrons collide with boron compounds, creating mini nuclear explosions. Once treated, the dying cell flares up (scanning electron micrograph, top). Finally, the cell collapses on itself (bottom).

PHOTOS: HIROSHI HATANAKA, TEIKYO UNIVERSITY (JAPAN)

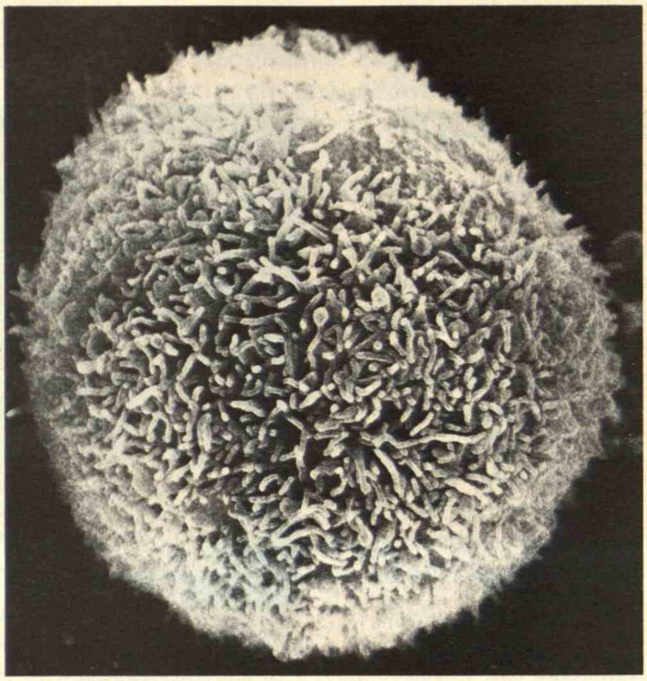
therapy and radiotherapy are not very successful in treating glioblastomas because they destroy both normal and cancerous tissue in the immediate area. Theoretically, the neutron-capture reaction would be a more effective means of treatment since it can be targeted on cells containing boron.

Despite this theoretical advantage, the experiments at M.I.T. and MGH failed. According to Hatanaka, there were a number of reasons why. First, the boron-10 compound was injected into the patients' bloodstream only a half-hour before the neutron therapy began. This left little time for the compound to clear the brain's blood vessels and settle in tumor cells. Also, the compounds used in the early experiments did not bind particularly well to the tumorous tissue. As a result, excessive concentrations of boron remained in the blood vessels. When the neutrons were "captured" by those remaining borons, massive destruction of blood-vessel walls ensued, causing hemorrhaging and death.

"From that point on, neurosurgeons in this country decided this was something they didn't want to use," said John Kirsch, a postdoctoral research fellow at MGH. "But all through the 1960s, the group at MGH continued to look for a compound that would clear the blood and bind to the tumors."

Successful Trials

In the late 1960s, researchers at MGH purified a boron-containing substance called B12-H11-SH that seemed to bind tightly to tumor proteins. The MGH group began using the compound in animal experiments, but in Japan, Hatanaka undertook human clinical trials. He found that if he injected massive doses of steroids into the patient's brain prior to treatment, the blood-vessel walls would be protected. "With the steroid treatment, a high level of boron in the bloodstream is not as dangerous," Kirsch said. "Hatanaka did some beautiful research in making that discovery."



A brain tumor cell is shown before treatment in this scanning electron micrograph photo.

Hatanaka's treatment differed from the previous attempt at M.I.T. in two other important respects. He injected the boron compound into the patient's carotid artery a half-day before the neutron therapy instead of a half-hour. And he irradiated the entire brain instead of a small portion.

"Irradiating the whole brain produces 10 or 20 times as many neutrons in the central part of the brain, where most of these tumors grow," Hatanaka explained. As long as the boron is concentrated only in the tumor cells, slow neutrons have no effect on normal brain tissue. But in tumor cells, the neutron-boron combination is lethal.

From his own experience as a neurosurgeon, Hatanaka also knew that when tumor cells die, they suddenly flare up in size, often causing respiratory arrest in patients. So he developed a surgical method of removing the center of the tumor prior to the neutron-capture treatment. With its nucleus gone, the dying tumor would implode on itself. "This surgical technique also helps avoid the toxic effect of tumor debris on normal cells," Hatanaka said. "It's a very important part of the therapy."

At first the Japanese physician was able to use this regimen only as a last resort on patients who had had no success with chemotherapy or radiotherapy. The results were not spectacular. Then in 1972 he received permission from the Japanese government to employ neutron-capture therapy on patients without any previous treatment. Of the 40 patients he treated before 1979, 33 percent were still alive after five years. The longest-surviving glioblastoma patient, treated in 1972, is now a healthy 61 years old. These results compare very favorably with the most successful results ever reported using conventional radiotherapy: a five-year survival rate of 5.7 percent at the Mayo Clinic in Minnesota.

Hatanaka also reports that he has not lost any of the 12 patients treated for glioblastoma since 1979, nor have there been any recurrences of cancer. "I am convinced that in another 20 years, we will be able to achieve an 80 percent five-year survival rate," Hatanaka said, "but only if a good collaborative study can be organized."

Hatanaka says he is restricted from doing a major clinical study of neutron-capture therapy in Japan because of the limited size of the reactor he uses (0.1 megawatt). "A larger reactor would be more beneficial because I could treat three patients a day," Hatanaka said. "Now I can treat only one."

Even though large reactors are more common in the United States (M.I.T.'s reactor is 5 megawatts), substantial obstacles remain to the use of neutron-capture therapy here—mainly medical protocol. "The protocol in the United States is to try conventional therapies before attempting an experimental treatment," Kirsch said. "Yet Hatanaka's most successful results have been with patients who had no previous treatment. That seems to be an almost insurmountable roadblock to therapy here."

A growing number of U.S. researchers, spurred by Hatanaka's success, are forg-

ing ahead anyway. At the M.I.T. conference in October, these researchers reported on a new approach to neutron-capture therapy: tagging the boron compound to antibodies that seek out and combat specific tumor cells.

Conventional antibodies are protein molecules produced by the body's immune system in response to any foreign substance, or antigen. Antibodies have binding sites where they combine, in a lock and key mechanism, with antigens. This antibody-antigen complex is destroyed by other parts of the immune system. Scientists have already found a way to produce "monoclonal" antibodies, which recognize specific "tumor-associated" antigens, and they are hoping to eventually tag cancer-fighting drugs to these antibodies. By using such antibodies in neutron-capture therapy, they may finally be able to eliminate the specter of boron remaining in the bloodstream like a timebomb waiting to explode.

—Alison Bass □

Personal Computers and Airlines: Mutual Interference

The advent of lap-sized, battery-powered computers—not to mention portable video games and other electronic equipment—has created a dilemma for commercial air carriers. They do not want to restrict their passengers' ability to work while flying, but they take very seriously the radio frequency interference (RFI) that can be generated by electronic devices brought on board.

RFI is, of course, common. Electromagnetic radiation normally emitted by electric and electronic equipment can interfere with other electronic equipment. For example, such interference causes the fuzz that appears on a television screen when a vacuum is turned on or a neighbor transmits over a CB radio.

The receivers on an airplane's navigation and communication equipment may also pick up stray electromagnetic radiation and process it along with true signal information, says Tom Barton, an engineer in the avionics section at Eastern Airlines. Thus, pilots can get garbled readings on their instruments. For example, the electromagnetic radiation from an FM radio operating in the cabin has been known to affect the needle on the crew's direction-finding equipment, which depends on radio signals from the ground. Theoretically pilots could get steady but incorrect readings because of RFI and not know it. What is more likely, says Barton, is that an alarm on the directional system will warn pilots of a "false deviation." So far, no serious accidents have been documented as resulting from RFI.

The Federal Aviation Administration (FAA) banned electronic devices from aircraft more than 25 years ago. In 1966 the FAA amended its regulations to permit pacemakers, hearing aids, voice recorders, and electric shavers. The FAA also gives airlines the right to exempt other electronic devices from the restrictions, as long as the airlines have determined that these will not interfere with the equipment on board. This is where the problem gets sticky.

The Unknown

So many calculators, computers, and electronic games are on the market, with more appearing every week, that it is impossible to check each new product for its effect on avionics systems. Both the FAA and the airlines strongly oppose a testing program because it would require an enormous and continual investment. Testing the required navigational aids and keeping them from interfering with each other is itself a huge job, one obviously more important than checking out innumerable devices that will appear in unknown quantities and random locations in the aircraft cabin. It is simpler, for now, merely to issue a blanket restriction.

Representatives of the FAA and major airlines admit that personal computers probably won't cause any more interference than calculators, which are approved by most airlines for passenger use. Indeed, airline crews themselves occasionally use calculators. "The radiation power of these devices is very small," notes Frank Rock, an FAA engineer. "Moreover, the critical systems in the aircraft are redundant and fairly well protected. The antennas for most of the navigational equipment tend to be placed far from the cabin on the wings, nose, and tail." Barton doubts that most digital devices pose much danger, especially on newer aircraft where navigational equipment is able to detect interference. Nonetheless, he says, "the unknown is what worries me."

ILLUSTRATION: JON McINTOSH

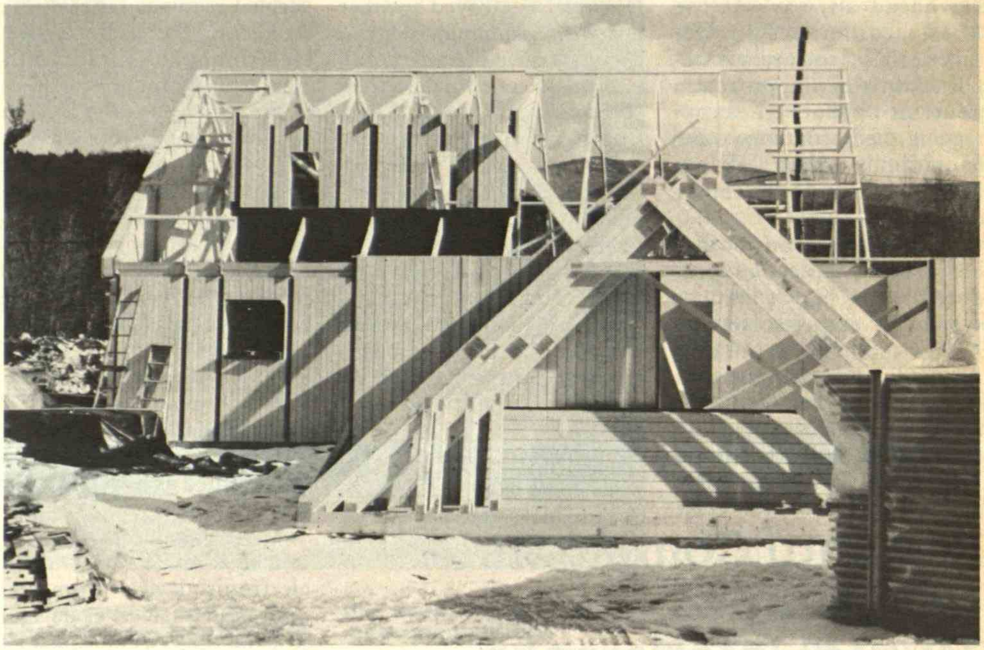
Establishing Standards

What the industry needs, according to Barton, are specifications that can be given to manufacturers of electronic equipment. Any product meeting those specifications would then be allowed on commercial aircraft. The Airline Electrical Engineering Committee, an international organization responsible for instrument specifications, is working on the problem and plans to develop a standard for the electronics industry.

Until then, the airlines will continue to make their own rules, enforced at the discretion of pilots and crews. Rules vary from one airline to another, and even from flight to flight on the same airline. For example, Eastern Airlines permits the use of calculators but not microcomputers. However, flight attendants are given no guide as to what distinguishes a calculator from a computer—a judgment that is increasingly difficult to make.

Passengers can check airline policies before flying, but even that doesn't always yield clear answers. Reservation clerks from two airlines said that no electronic devices could be used on board, but senior officials maintained that their policy was not so strict. In any event, flight attendants should be informed of devices passengers plan to operate—in case the pilot notices irregular behavior in the navigational equipment.

—Christopher D. Earl



U.S. Homebuilders: Competition from Abroad

Energy-efficient Swedish homes have already sprouted from England to Saudi Arabia, and they are trickling into the United States. The Lexington Development Corp. (LDC) of New York city has built 20 and has 100 more on the drawing boards. LDC hires local architects to design the homes to insure that they conform to local codes and aesthetics. LDC then sends the plans to Sweden. There, panels are assembled in local factories and shipped to the United States; the transportation cost is about $5,000 per house. A four-person crew puts up the house in a day or two. One of the projects LDC has built is a resort community of about 18 homes in Sugarbush, Vt. These houses of roughly 2,000 square feet would sell for about $100,000, not including the land.

The Minnesota Housing Finance Agency (MHFA), which is planning to build a demonstration development, claims that Swedish houses would even be competitive there—halfway across the country. The MHFA predicts that houses of 1,200 to 1,500 square feet could sell for $75,000 to $85,000 complete—including land, utility hookups, and landscaping.

Tight as Ships

The biggest selling point of the Swedish homes is their extremely high energy efficiency, which is largely a byproduct of their exceptional workmanship. "The Swedes have a building technology far superior to anything in the United States today," said James Solem, executive director of MHFA. MHFA hopes that its proposed project will inspire similar quality from Minnesota builders, rather than massive imports of Swedish homes to the state.

"Swedish tolerances are much stricter than ours," said Paul Kando of the National Association of Home Builders Research Foundation, who recently toured Sweden. "The Swedes dry lumber to 10 to 12 percent water content; we dry ours to 15 to 19 percent. This means that their houses shrink less and crack less." He added that Swedish construction is so meticulous that windows are installed with rubber gaskets instead of caulking.

Furthermore, the Swedes build houses in an integrated way, not as a collection of ill-fitted components, said Kando. "They build the whole house with the idea of delivering a certain energy performance. By contrast, U.S. builders who want to improve energy performance

PHOTO: LEXINGTON DEVELOPMENT CORP.

Swedish builders are producing homes that are so well constructed and energy-efficient—at such reasonable prices—that the homes are actually being imported into the U.S. Left: Components of a Swedish-built home being assembled in Sugarbush, Vt.

just make the same houses as always, but add energy features without integrating them."

Grinding Out Homes Like Sausages

Swedish homes have long been energy efficient and of high quality, as a result of factors ranging from cultural traditions to government policy. But factory production of homes in recent years has led to further improvements. "Swedish industry grinds out very efficient buildings like sausages," said Henry Kelly, a project director at the congressional Office of Technology Assessment, who toured Swedish house factories with Kando.

Swedish factory production allows for high quality in a number of ways, according to a draft report by the American Council for an Energy Efficient Economy (supported by the German Marshal Fund of the United States). For example, consider the vapor barrier—a metal foil or membrane placed next to insulation to prevent humid inside air from seeping into walls, condensing, and causing deterioration. Vapor barriers are especially important in well-insulated houses. These barriers are checked in Swedish factories to be sure the seal is tight, and the seal can be maintained at places where the membrane meets windows and doors. This sort of quality is hard to achieve in on-site construction.

Swedish construction companies maintain a well-paid labor force year-round instead of hiring and firing seasonally, as U.S. builders do. Workers are encouraged to take courses to improve their skills. Swedish companies also employ technical staffs and conduct research and development to a far greater extent than U.S. home builders.

But Swedish quality is not just a technological achievement. Swedes have faced energy shortages for a long time and they built energy-efficient houses even before the 1973 oil embargo. They demand better housing because they spend more time in their homes through the long winters than Americans do, and because they keep their homes for 20 years, as compared with 5 to 7 years on the average in the United States. Swedish builders feel that the market rewards higher quality, according to the report of the American Council for an Energy Efficient Economy.

The Swedish government issues regulations to promote good construction, and builders could hardly be called reluctant to follow them. In fact, almost all builders already meet the 1985 energy-efficiency standards. "In Sweden the building standards are accepted by consensus," said Kando. "They are viewed as an opportunity for the quality-conscious builder to remain competitive."

Builders are eager to follow standards partly because the Swedish tax system rewards homeowners who make investments that pay off in the long run. "Swedes try to invest their way out of consuming," according to the American Council report. Loans for new homes in Sweden give "generous" support to energy-conservation measures but are "spartan" toward luxury items. And virtually no home buyer loses a chance to qualify for a loan because of small additional costs for energy conservation, according to the report. Bankers in Sweden also have the engineering backgrounds necessary to judge the merits of such loans, unlike their U.S. counterparts.

"The Swedes decided to build energy-efficient homes and succeeded," said Kando. "We in the United States never decided to, so it's not surprising that we fall short."
—*David Holzman* □

U.S. Homebuilders: Ignoring Solar

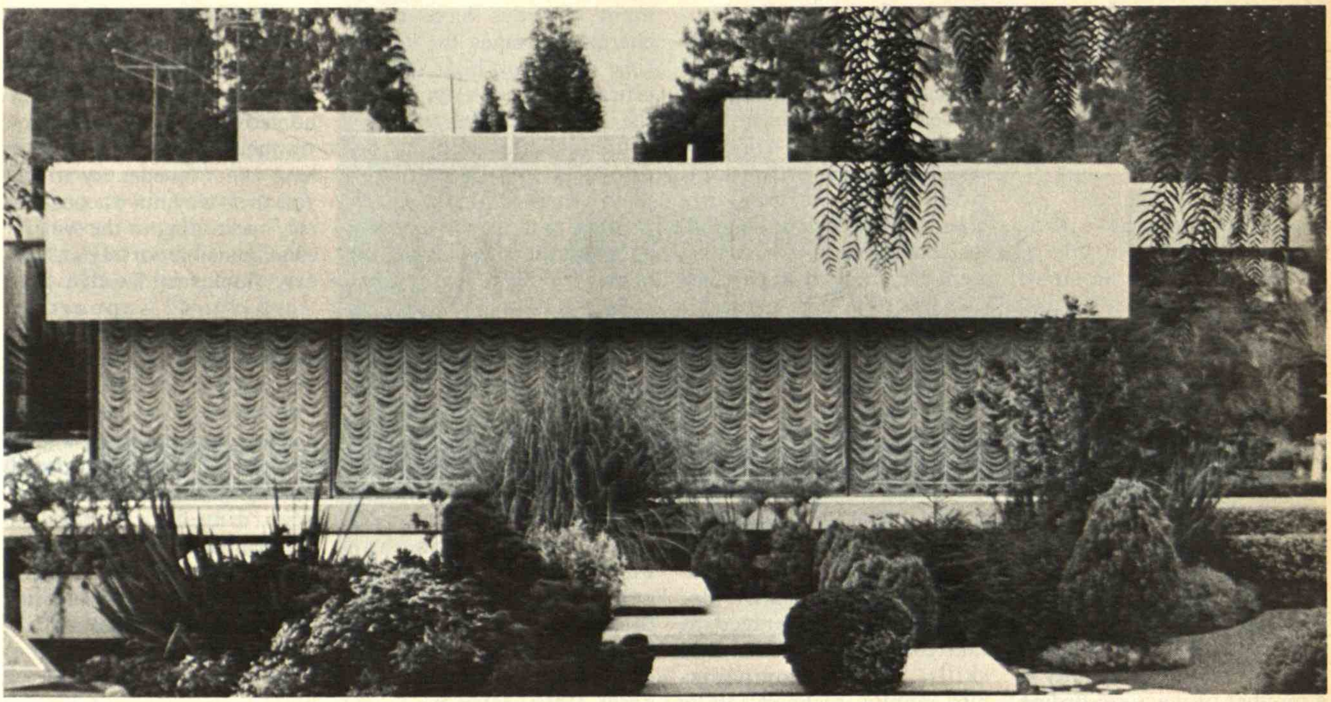
Whether many forms of solar energy are practical for widespread use is still debatable. Solar collectors for industrial heat are restricted to favorable geographic locations. Photovoltaic cells that turn sunlight directly into electricity are competitive only for specialized applications, such as the microwave repeater stations in Australia that bring telephone service to the "outback." But passive-solar architecture, which merely configures houses to take maximum advantage of the sun, is clearly practical anywhere in the contiguous United States.

Buildings can be designed to block the rays of the high summer sun. They can absorb the warmth of the low winter sun, store it in wall masses, and release it as needed at night and on cloudy days. Shortly after the energy embargo of 1973, the American Institute of Architects estimated that passive-solar design would add little to the cost of buildings yet save half of their energy costs. In the decade since, one might have expected homebuyers to demand passive solar and builders to employ it.

That hasn't happened. At the Passive Solar Update Conference, held by the Department of Energy (DOE) last October, speakers repeatedly chided the building industry for its failure to incorporate passive-solar features in homes. The 300 largest builders in the country, responsible for 40 percent of new homes, do not use passive solar, according to Sumner Rider Associates, a New York public-relations firm with numerous builders as clients.

"The housing industry has not been innovative," agreed Mike Bell, manager of energy programs at the National Association of Home Builders (NAHB). "Builders react to market trends instead of setting them." But Bell said that a couple of the big companies have experimented with passive solar. "If homebuilders wanted to market passive solar, they could," said Harrison Franker, an architect in Princeton, N.J. He suggested that this would allow consumers to lower their monthly costs: slightly higher mortgage payments would be offset by lower utility bills. And Mark Conkling, project director of the New Mexico Showcase of Homes, a consortium of 16 builders who are putting up affordable passive-solar housing, was more optimistic. "We're past the early adopter stage," he said, "but not yet into the mass-market stage."

Most homebuilders and homeowners aren't exactly attuned to the principles of passive solar design. In this Southern home, sunlight pours through the picture windows; the heat is absorbed by the curtains and passes inside. Only shutters outside the glass could keep the heat out.



By Fits and Starts

Even when U.S. builders incorporate passive solar, they generally "tack on" features—a less effective and more costly method than integrating energy efficiency into the overall design, according to Paul Kando of the NAHB Research Foundation.

The foundation's annual survey of NAHB members provided some insights. Of thousands queried, only 772 builders—most with small operations—responded to questions on solar, and just 108 of these had built any passive-solar homes in 1981. Furthermore, one-third of these builders of passive solar had failed to include all the components that comprise a passive-solar system. As defined by the Department of Housing and Urban Development, these include collection, storage, distribution, and control features requiring little or no external power.

The problems from these poorly integrated systems have been predictable, said Kando. Buyers' complaints, as expressed by builders in the survey, include too much or too little heat and fading carpets and furniture.

The majority of builders who avoided passive solar found its cost intimidating. Kando blamed this on the lack of an integrated approach to solar architecture: "putting solar glazing on a sieve is like trying to justify a gate without a fence."

Some builders were skittish about experimenting with passive solar in a slumping market. Most complained that information on passive solar was hard to find. Charles Hauer, a consultant to the DOE Passive Solar Program, suggested that passive solar might simply be too complicated for most builders. He referred to Don Aitken, a successful passive-solar builder in California who holds degrees in physics, architecture, and mechanical engineering. If this is the kind of education it takes to build passive solar, Hauer seemed to be saying, we might as well forget it.

Consumerism

Another common complaint about passive solar is that consumers are not interested. At the conference Conkling explained that 99 percent of home buyers seek good financing, 63 percent look for microwave ovens, 30 percent are swayed by "romantic and spacious bathrooms," but only 1.5 percent base their decisions on solar.

Conkling urged builders to give consumers what they want and include solar in the deal. His consortium of builders in New Mexico provides 9.5 percent financing on houses costing $75,000 to $105,000. Builders who lack Aitken's education can calculate energy savings from a worksheet the consortium uses, which is complex but no worse than income-tax form 1040. Because Los Alamos National Laboratory developed it, the worksheet carries weight with local bankers, some of whom allow people to qualify for higher mortgages based on projected energy savings.

The NAHB Research Foundation concluded that good passive-solar designs are cost-effective, and that builders' and consumers' ignorance of this fact is the biggest obstacle to widespread use of passive-solar design. The foundation urged the DOE to continue monitoring test houses through the Passive Solar Program to provide the information builders need. But Kando warned that recent cutbacks could kill the monitoring program just as results are due.—*David Holzman* □

PHOTO: STOCK BOSTON

Personal Computers and Corporate Culture

B*y their very name, personal computers (PCs) seem to promise users a certain independence. Today, these seemingly autonomous sources of information are spreading through the offices of corporations. Some observers see them as the embryos of the electronic work stations that may one day tie together all the workers in an organization. Yet management-information-systems (MIS) departments, which control other corporate computers, are often constraining PC users in a bureaucratic web.*

As vice-president of the Diebold Group, Joseph Ferreira is a consultant to many corporations–and talks with hundreds of executives–about PCs. Ferreira himself has 25 years of experience in MIS and uses two personal computers at work. Jonathan Schlefer, a senior editor of Technology Review, *recently asked him about the dilemma of the personal computer in corporate culture.*

How quickly are personal computers being adapted by large corporations?
There's a tremendous range. Some companies don't see having many PCs for years; a few like United Technologies and Travelers Insurance are installing thousands today. Right now I would say the average Fortune 500 company probably has only 200 to 300—mostly Apples, TRS-80s, and now IBM PCs, plus a smattering of others. I expect that figure to double in a year, and eventually I think PCs will be as commonplace as telephones.

In the meantime, how are corporations handling the introduction of PCs?
Again, there's a spectrum. At one pole companies say: I'm going to tell you what PC to use, and I'm going to measure how you use it. At the other end are companies where you might not know what to do with a personal computer—might not know anything about it—but you just go out and get one. I don't think either extreme makes sense.

Where are most corporations on this spectrum?
Most are control-oriented.

What kind of control do they exercise? Why?
MIS executives know that managers who get PCs will make mistakes. They'll buy hardware, but then the manufacturer will go out of business, as Osborne did. They'll buy PCs that will be unable to communicate with the mainframe or other PCs. They'll buy software, but it won't work the way they want, so they'll go out and buy more. They'll purchase 10,000 individual PCs and lose the economy of large-scale buying. And there will be no vehicle to share experiences, no corporate learning.

MIS executives don't want this to happen. Also, they themselves have been overcontrolled by top management. They struggle for resources, and all of a sudden they see money being spent on computers without guidance and outside their jurisdiction. They feel frustrated.

So MIS sets up policies. Many are valid, but they can also become just another example of trying to establish control: You can't buy a PC unless MIS signs off on it. Any PC you buy has to be one of three models. You can't buy one unless you can show a payoff in X months. You have to use certain software.

If you have a PC, MIS will monitor how you use it. I've heard MIS people talking about things that I don't even think can be validly done. They check how many hours per month you use your PC to see whether you need it. But a PC really has to be on all day—you don't want to have to charge it up and key in every time. Then how much are you actually working on it? MIS looks to see how many hours it is connected to the mainframe. You may have to fill out forms on how you use your PC. Big brother knows best.

But surely, users will make costly mistakes with thousands of PCs.
Yes. But if you try to engineer out all the mistakes, there is a certain amount of learning that won't take place. It's like trying to rule all the mistakes out of adolescence. All you have to do is lose the information on one disc to realize the value of backup.

I'm not saying that there shouldn't be any rules governing PCs, but I think users should be involved in making them. You can't simply promulgate the wisdom of MIS because they know 40 things users are going to do wrong. Many MIS executives don't even have PCs, and it isn't really possible to learn about them secondhand.

What about the trivial uses? Aren't PCs often used as toys?
PCs are being used for trivial things and significant things. Some managers use them only to keep calendars—pretty expensive calendars. But you shouldn't be too quick to condemn "trivial applications." The most important return may be that people are getting comforta-

ILLUSTRATION: JON McINTOSH

ble with a new tool that will be an important part of their work.

Then you don't believe in measuring efficiency?
There's too much concern about efficiency before people know what they're doing. It's like trying to measure kids crawling. You feel you've got to get them to run first—they shouldn't waste time crawling or walking.

Look at payback: how do you measure it? If you tell me I can't buy a PC unless I can prove it will pay off in a year, I will say that I spent more money painting my office—and I can't show you the return for that. People may use phones inefficiently. But tell me who's going to take them out if corporations do zero-based budgeting. People do a lot of things inefficiently. Life goes on.

What happens if corporations are too heavy-handed in restraining the spread of PCs?
Practically everybody who works with information can use a PC. If you don't want to buy me one, I can buy it myself. Are you going to tell me I can't bring it into the office? I have paper, a phone. You really can't deny me these things.

And what are you going to do with students coming out of colleges where they used computers? Are you going to tell them they can't have PCs? They can have them in this part of the organization but not in that part? You're not going to attract those workers unless that tool is there.

PCs seem to touch a lot of issues in white-collar work.
Yes. So much white-collar work is discretionary. You talk as long as you want on the phone, have meetings of indeterminate length. You stop doing something and shift to something else—which has inefficiencies, but also gives you new vigor. This kind of work can't be engineered. To improve productivity, the control that corporate cultures are used to has to be changed to allow workers more leeway.

The personal computer is an aspect of this. I don't even say it is the most significant aspect, but it becomes a symbol. It draws new attention to the way people work: technology carries that aura.

Everybody always asks: why does my boss have a bigger office? But now something new can help me, and I'm going to fight to use it the way I want to before the rules are set in concrete.

What is it about the actual technology of PCs that makes them such an issue?
A PC enables you to do things you cannot do without it, just as engineers can design circuits that they simply could not without computers. When I do a budget, the more tools I have—to lay numbers out, run curves, change variables, extrapolate patterns—the more energy I can put into the thinking. With a PC I can put more energy into writing a report—I am free to explore more alternatives—because it is much easier to do the mechanics.

The PC is an example of small is beautiful. I can buy one and start doing things. I don't have to depend on engineers or compete with others for resources, and the way a PC works is reasonably easy to understand. It gives that sense of control over destiny. It has an almost instantaneous response time, in sync with the way a person thinks. A PC—a personal computer—touches the individual. □

Nuclear Research Mounts a Defense

In a referendum with national significance for many academic institutions and high-technology companies, voters in Cambridge, Mass., turned down the so-called Nuclear Free Cambridge Act. The terms were that "no person, corporation, university, laboratory, institution, or other entity shall, within the City of Cambridge, engage in work the purpose of which is the research, development, testing, evaluation, production, maintenance, storage, transportation, and/or disposal of nuclear weapons or the components of nuclear weapons." The referendum went down by a vote of 17,331 to 11,677.

Analysts pinpointed two major reasons for the failure of the referendum, which had enjoyed a two-to-one advantage among Cambridge residents polled four months before the vote. The decisive issues were academic freedom and jobs.

Mobilization for Survival, the group that sponsored the referendum, insisted throughout the campaign that its target was the Charles Stark Draper Laboratory. An institution employing about 1,800 people, the laboratory designs guidance systems for MX, Trident, and Pershing missiles. Although Draper separated from M.I.T. in 1972, officials at M.I.T. and Harvard University saw the proposed ban as a threat to academic research. "I might have had to go to court to prove that I wasn't disobeying the act in my studies of nuclear disarmament," argued M.I.T. physicist Kosta Tsipis.

Reacting to that concern, a number of prominent faculty members at the two universities—including leaders of the arms-control community—helped to form a group named Citizens

Against Research Bans to oppose the referendum. In addition, M.I.T. President Paul Gray and Harvard President Derek Bok expressed their strong opposition to the proposed ban, on the grounds that it could abridge the universities' commitment to free inquiry.

Opponents of the nuclear-free initiative also made a major issue of Mobilization for Survival's claim that Draper could easily move into new lines of work, unrelated to nuclear weapons. Mobilization staffer Susan Levene admitted that "alternative-use plans" for Draper would have to be considered thoroughly later, on the basis of studies of

Members of Mobilization for Survival demonstrate outside Draper Laboratory. Voters defeated their proposal for a nuclear-free Cambridge.

PHOTO: AL PEREIRA

companies that have transformed themselves."

Despite its defeat at the polls, the group claimed a moral victory. "This is the first time in the country that a community has targeted the nuclear industry," said Levene, "and we were outspent 20-to-1."

The Cambridge vote is just a prelude to other nuclear-free efforts elsewhere in the country. One major target for next year is Santa Barbara, Calif., an area housing a number of nuclear-weapons contractors. And both Mobilization for Survival and Draper are gearing up for a possible rerun of the issue in Cambridge in 1985.

—Peter Gwynne ☐

Competing with Chips, Settling Space

Competing with Chips

The Amazing Race:
Winning the Technorivalry with Japan
by William H. Davidson
John Wiley & Sons, $17.95

The Fifth Generation:
Artificial Intelligence and Japan's Computer Challenge to the World
by Edward A. Feigenbaum and Pamela McCorduck
Addison-Wesley, $15

Reviewed by Michael Riordan

As the Europeans and Japanese compete ever more successfully in the U.S. and world marketplace, we hear a chorus of pleas for American industry to put its house back in order. Most observers advocate all-out economic warfare with Japan. This competition is viewed as a survival of the fittest—a struggle to the death with the winner taking all the spoils. Either we fight and win, or we resign ourselves to becoming the vassal state of our Japanese masters. The overwhelming emphasis is on *domination*, not on international cooperation or exchange. "If only we could focus our efforts," exhort Edward Feigenbaum and Pamela McCorduck in *The Fifth Generation*, "we should have little trouble dominating the second computer age as we dominated the first." Though not as strident, William Davidson in *The Amazing Race* is hardly better. As their subtitles suggest, both are strategic planning manuals for waging economic warfare with Japan.

Davidson, an associate professor of business policy at the University of Virginia, examines a major theater of the growing conflict: computer and communications equipment and services. If current trends persist, claims Davidson, this industry will contribute about 40 percent of world industrial value—or about 1.5 trillion dollars per year—by the turn of the century. Thus, in the Information Age, many argue, those who control the manufacture of information-processing equipment will control the world economy. The information industry is particularly crucial to resource-poor Japan because it requires only small inputs of energy and raw materials and re-

turns high value added per worker. It is the perfect arena for Japan to assert world leadership through industrial activity—its goal since the Meiji restoration in the nineteenth century.

Feigenbaum, professor of computer science at Stanford, and McCorduck, a science writer, look at an important future battlefield: the production of "intelligent" computers that can reason and inform. They warn that Japan will be able to manufacture such thinking machines on a mass scale before the turn of the century. Such an ability will prove to be America's Waterloo; it will make Japan the dominant force in the postindustrial society now emerging in technologically advanced countries. Feigenbaum and McCorduck warn that Japan is totally committed to succeed in this flanking maneuver. Indeed, billions of yen and some of that country's best computer scientists are hard at work on the nationally planned and coordinated "Fifth Generation" project.

However, wars are rarely (if ever) fought for the benefit of the footsoldiers, and this war is no exception. Both books say a lot about national prestige and world leadership but very little about any real benefits that information technologies might bring to the average homemaker or factory worker. About all Davidson has to offer is the following comment from the preface: "In the information technology sector, the greater the pace and intensity of the race, the greater will be the benefits to world society. Competition between the United States and Japan in this sector is a positive and progressive force, one that will contribute greatly to economic and social progress."

This naive statement makes me wonder where Davidson has been hiding these past two decades. He certainly has not bothered to talk to any of the U.S. factory workers who—after 30 years on the assembly line—have lost their jobs to robots and been asked by their president to reeducate themselves for the glorious Information Age.

Global Marketplace

One thing is certain: the so-called information revolution will cause massive dislocations in our economy and society. It is already creating a huge pool of undereducated, unemployable workers with no place to go. The faster the revolution proceeds, the worse things will get for these people, who can no longer count on the sympathy and support of their government while making the difficult adjustment. Large segments of the U.S. population—and even larger segments of the world population—have absolutely no need for the supposed benefits of information technology. Do we merely shove them aside brutually as we build this brave new world?

The fact that Japanese industry, by contrast, is very concerned about the welfare of its laborers may be the true key to its recent success. By now, most people know how Japanese companies virtually guarantee their workers jobs for life. This security not only builds intense worker loyalty, something rare in U.S. factories; it also diminishes the threat that technical innovation might pose to workers' livelihood.

Davidson tells how Japanese workers, who constantly propose ways to improve efficiency, productivity, and safety, often suggest eliminating their own functions; they are then reemployed elsewhere or even promoted. And wages are tied to the overall productivity of the plant, so work-

ILLUSTRATIONS: ELIZABETH SLOTE

ers have every incentive to accept automation.

Thus, Japanese industry has a tremendous advantage in the Information Age because it treats its workers as valuable, intelligent, creative members of a team working for common goals. American industry, with its adversary relationship between labor and management, is simply no match for this dynamo. When American management tries to introduce labor-saving automation to the assembly line, workers accept it only grudgingly, often becoming sullen and even resorting to sabotage.

The top-down U.S. management style, which worked wonders during the Industrial Revolution and well afterward, seems bankrupt in an era where constant innovation is the norm. American managers who continue treating workers as unskilled, replaceable cogs in a huge machine do so only at their great peril. Some companies are introducing quality circles and other participatory forms of management, but Japan has a ten-year lead in this department. Given the already poisoned relationship between labor and management, American industry will be hard-pressed to catch up.

This spirit of confrontation between adversaries permeates both these books. It's either us or them—this time on a global scale—and the devil take the hindmost. But such an attitude is no more relevant to the global marketplace than it is to the factory floor.

Both books *could* have been written in a completely different spirit, one that—like the Japanese management style—stresses cooperation, exchange, and consensus policymaking that will benefit all parties. The world market for information technologies and services is a vast, complex ecology with many niches to fill and relationships to establish. If we are going to live in a global community, it's high time we begin to act like good neighbors. □

Michael Riordan is publisher of Cheshire Books and coauthor of the Solar Home Book. *He is currently working on a book on the discovery of the quark.*

Settling Space

The High Frontier
by Gerard K. O'Neill
William Morrow & Co.

Reviewed by Stewart Nozette

The first age of discovery in space is drawing to a close, and the next major challenges may well involve the practical utilization of space for economic as well as scientific ends. Space contains copious amounts of raw materials and energy, and people are beginning to contemplate how they may be put to use. The original 1977 edition of Gerard O'Neill's *The High Frontier* first outlined how to do this, stimulating a great deal of interest in the concept of large-scale space development. O'Neill's ideas, visionary for their time, still spark the imagination, and recent developments in the field have prompted the publishers to release a somewhat updated edition.

The High Frontier still brings to mind a quotation attributed to Henry David Thoreau, "If you have built castles in the air your work need not be lost: that is where they should be. Now put the foundation under them." O'Neill's concepts of space cities with thousands of inhabitants are grand, especially considering the economic and technical constraints on current NASA programs. And the technology may not develop quite the way O'Neill has in mind. Just as nineteenth-century engineers crudely sketched out aircraft that reflected the technology of the day (steam-powered paddle-wheel propulsion), large-scale space stations of the next century will probably bear only a crude resemblence to O'Neill's designs.

According to O'Neill, the principal reason for developing space colonies would be to deliver energy to Earth. This energy could be captured by orbiting solar collectors and transmitted to Earth as microwaves. NASA has investigated such a solar-power satellite, or SPS, intensively, as have corporations such as General Dynamics and Rockwell. Building the SPS would clearly be a massive undertaking dwarfing all current space activities, and no SPS research is now being funded in the United States. However, Japan is continuing to investigate the concept, using sounding rockets to test microwave propagation in the upper atmosphere as a precursor to testing the SPS complex.

O'Neill argues that the key to the success of an SPS or any large-scale use of space lies in building facilities from nonterrestrial resources, because launching the necessary mass from Earth would be prohibitively expensive. However, the costs of putting a factory to manufacture power stations into orbit would be similar to launching the whole power station from Earth. Thus, current work is aimed toward developing small-scale facilities that could be expanded as needed. For example, NASA is proposing to build a space station housing a crew of four to twelve people, who would monitor astronomical instruments and industrial experiments. If funded, the first modules of such a station could be in operation by the early 1990s.

Such a space station could also be used as a refueling depot. O'Neill notes that for the next two decades, an important commodity in space will be propellant, mostly liquid oxygen for transporting military and communications satellites from low orbit to high, or geostationary, orbit. Indeed, oxygen comprises 60 percent of the mass that must be launched from Earth to transport spacecraft to high orbit. Thus, a refueling depot that produces propellant derived from the moon and asteroids may

be the first economical use of a manned space station.

Water could be converted into hydrogen and oxygen for fuel and life support through electrolysis or other nonchemical means. Locating the most accessible water supplies on asteroids and the moon should therefore be one of the first goals of developing space resources. Metal for shielding high-orbit spacecraft could also be mined and manufactured.

The Solar System Exploration Committee, formed by the NASA Advisory Council, recently took a significant step toward initiating such projects by deciding to survey near-Earth resources. This survey will include the closest asteroids and a global mapping of the moon, filling in the gaps left by Apollo and checking for the presence of water at the lunar poles. Each mission could be completed for $100 million by adapting existing satellites. The exploration committee stated that "the demonstration of a profitable scheme for returning extraterrestrial minerals to Earth could open the door for total space industrialization, and hence a new age."

Laboratory work on processing of nonterrestrial materials is also proceeding at several locations. O'Neill's Princeton-based Space Studies Institute is sponsoring research at Rockwell International on extracting useful materials from lunar soil. NASA and the California Space Institute have been working on extracting oxygen from lunar materials by melting the rock and passing an electric current through the melt. And workers at the Jet Propulsion Laboratory and Johnson Space Center are also beginning to develop benchtop systems for processing nonterrestrial materials. This research is a first step in creating a new discipline of lunar and planetary technology, which combines aerospace technology with mining and chemical engineering.

Who Will Profit?

One area crucial to O'Neill's vision of maintaining people in space is biology: the design and construction of space-based farms, aquariums, and other life-support systems. However, space biology is in its infancy. So far humans have attempted to live in space for only about 200 days at a stretch, relying totally on Earth-supplied food. Growing food for colonies with many inhabitants will require much more experience. For example, work at several NASA centers and universities suggests that some form of artificial gravity may be necessary for growing plants in space. Thus, biology is one of the weakest links in the O'Neill scenario.

O'Neill points out that the cost of developing a space station and a vehicle for transferring satellites from low to high orbit would be comparable to that of terrestrial macroengineering projects such as the Alaska pipeline. However, private investors must be convinced that there is a market for the goods that will be produced in space before they will invest in such a venture. And an orbital-transfer vehicle and materials-processing techniques are only two examples of the technology that will have to be developed.

Also, the technical problems of developing the high frontier are not the whole story—a host of legal, managerial, and social questions exist as well. Who has jurisdiction over space resources, who will profit, who will regulate? The United Nations has ratified an Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, dubbed the "Moon Treaty." This agreement declares the resources of space to be "the common heritage of mankind," much like the resources of the deep ocean. However, the two major space-faring nations, the United States and the Soviet Union, have not signed it.

Furthermore, the organizations that will eventually exploit space on the scale depicted in *The High Frontier* exist today only in embryonic form, if at all. New international public-private entities with innovative charters and management structures will be needed, much as new ocean trading capabilities spawned organizations such as the Dutch East India Co.

A final difficulty with O'Neill's vision is that he and other space enthusiasts often imply that life in space will be a utopia. However, all will not be comfort and greenery in the beginning—in fact, life in space may be highly regimented. To gain public support, space stations must not be viewed as escapist but rather as the natural result of advances in space technology.

Indeed, the development of the high frontier is already beginning; the main question today is how long it will take. ☐

Stewart Nozette is a faculty member of the California Space Institute in San Diego, which is part of the University of California.

From left to right:
Dr. C. Denis Mee, IBM Magnetic Recording Institute, San Jose, California.
Dr. Werner Kulcke, IBM Manufacturing Technology Center, Sindelfingen, Germany.
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Can We Turn Down the Heat on the Faculty?

Strains and pressures on the M.I.T. faculty are "seriously eroding the quality of academic life and . . . may discourage the very best young people from selecting academic careers," says Paul E. Gray, president of M.I.T., in his annual report.

The problem arises in three areas that Gray discusses—but to which he offers no solutions:

□ The pressure to obtain financial support for research. As it turns out, faculty members are responsible for obtaining grants to support most of the research that brings distinction to M.I.T. . . . Some of that grant money typically covers a portion of professors' own salaries as well as stipends for graduate and postdoctoral—and sometimes undergraduate—students. Last year, says Gray, the average faculty member in a field where sponsored research is a major factor raised $300,000. The process—the result of a vast amount of discussion and proposal-writing—involves "an extraordinary amount of time and energy" that might better be spent otherwise. Furthermore, says Gray, the necessity for sponsorship may impose "real constraints on the ideas and research directions a faculty member might pursue."

□ Rapid changes in student interests, resulting in rapid fluctuations in enrollment, are causing severe problems in the School of Engineering and especially in the Department of Electrical Engineering and Computer Science. Indeed, says Gray, one of every three M.I.T. undergraduates who has chosen a major is now in EECS, whose enrollment has doubled in a decade. Though there have been some staff and faculty additions, Dr. Gray believes that the teaching pressures in that department are "well beyond reason."

□ The slowing of overall growth during the past decade has resulted in reduced turnover in tenure positions, for which the competition is now very high. Almost 70 percent of the faculty has tenure, says Gray, and their ages suggest that "only a modest number of retirements" will occur during the balance of this decade.

Most of these problems affect junior faculty most severely, and Gray pledges for them an effort "to preserve and enhance the quality of M.I.T. as a congenial, stimulating, supportive setting." □

Uncertainties Argue Against the MX

The "window of vulnerability" that is alleged to require deployment of the MX land-based missile may be very small—and may not even exist at all, say two researchers in M.I.T.'s Program in Science and Technology for International Security (PSTIS).

Their argument is that any large-scale attack aimed at silos containing U.S. intercontinental ballistic missiles would be subject to many technical and operational uncertainties. Kosta Tsipis, PSTIS director, and Matthew Bunn conclude that the outcome of such an attack "is essentially impossible to predict." The best they can say is that somewhere between 50 and 90 percent of all targets would be destroyed.

Four reasons for this large uncertainty, say Tsipis and Bunn:

□ The destructiveness and reliability of strategic weapons can only be estimated because of the basic limitations of peacetime testing.

□ The hardness of the target silos is extremely difficult to predict because no silo has ever experienced a nuclear blast.

□ The precise effects of "fratricide," when one exploding warhead deflects or destroys other incoming warheads, can never be tested.

□ The possibility of systematic biases large enough to have some significance, arising from gravitational errors, targeting uncertainty and atmospheric variations, cannot be completely ruled out.

Anyone attempting to make a technical prediction, they conclude, is faced with extraordinary complexity—"an attack involving hundreds of intercontinental missiles delivering thousands of thermonuclear warheads over variable ranges to more than a thousand separate targets."

The uncertainty may be less in the future, Tsipis and Bunn admit. "Once intercontinental ballistic missiles are twice as accurate as is necessary to ensure destruction of the target, variations of 10 to 20 percent in accuracy, yield, and silo hardness will no longer be of much importance, and the purely technical feasibility of such an attack will be much increased."

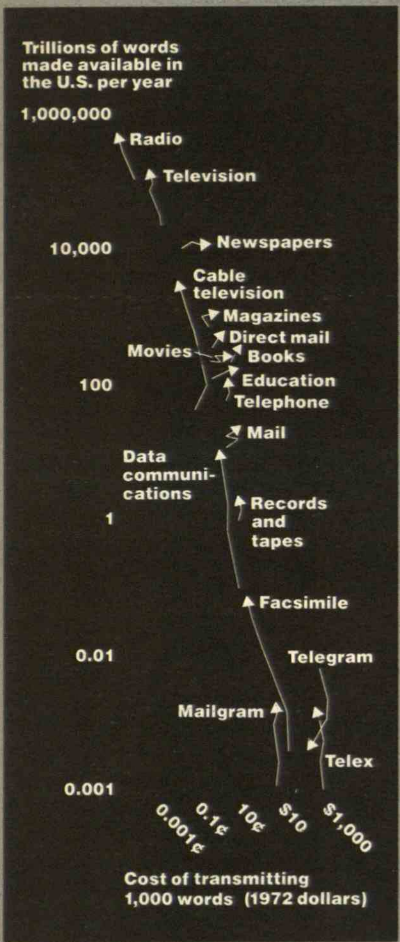
But that is a matter for small comfort. Tsipis and Bunn say that such developments would be "profoundly destabilizing and would represent a significant decrease in the security of both the United States and the Soviet Union." □

Computing in Concert

The head of M.I.T.'s Laboratory for Computer Science calls it "a revolution within the computer revolution . . . the foundation for making machines that see and can understand human speech."

The object of that extravagant emphasis is the research conceived by Robert H. Halstead, Jr., assistant professor of computer science and engineering, to link 32 of today's most powerful microprocessor chips into a single multiprocessor.

Each of the chips has the same power as many of today's full-fledged computers, and the real issue, says Halstead, is to make all these chips work efficiently in parallel. It's like the problem of four office workers trying to deal with correspondence from a single file at once—an organizational task, he says, "having to do with identifying separate tasks and providing for the necessary communication between the chips." If Halstead succeeds, the program will live up to its experimental name: "Concert." □



Trends in volume (vertical) and cost (horizontal) of communications between 1960 and 1977 (note logarithmic plots), as reported by Professor Ithiel D. Pool of the M.I.T. Department of Political Science. Mass media occupy the top-left quandrant of the chart, with more expensive person-to-person systems at the lower right. The gap between the two is now being bridged by sending data communications through computer networks, moving person-to-person communication into costs typical of mass media.

Continued from page 63
neutron-producing reactors, such as producing hydrogen from water through high-temperature electrolysis. Another possibility is using fusion neutrons to produce fissile fuel from thorium or uranium-238. This fuel could be used in nonbreeding fission reactors, such as the improved small reactors Lidsky mentions.

Neutron-Free Reactors

The one form of fusion power that Lidsky recommends is that based on neutron-free reactions such as hydrogen-boron. Because of their very low reactivity, neutron-free fuels will be extremely difficult to burn and are likely to have a much lower power density than deuterium-tritium fuels. The reader is left wondering why Lidsky disregards the power-density issue when discussing hydrogen-boron reactors and emphasizes it when comparing deuterium-tritium fusion reactors with fission reactors.

While the possibility of neutron-free reactors should not be ignored, there is no reason to identify them as the only real hope for fusion. And further work on neutron-producing reactor concepts would probably be necessary in the attempt to ultimately develop neutron-free reactors.

The Future

During the coming decades, the progress already made in fusion science is likely to be matched by strong and well-coordinated progress in both fusion science and engineering. There are only a limited number of long-term energy options, each with its own environmental-impact and cost issues. Future societies could regard the advantages of fusion as very important, and these advantages may well be attainable at an acceptable cost.
Daniel R. Cohn
Cambridge, Mass.

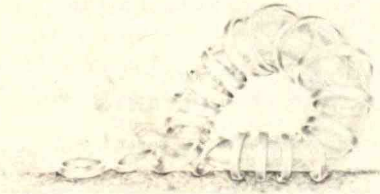
Dr. Cohn is a senior research scientist in the Plasma Fusion Center at M.I.T.

Professor Lidsky responds:
Dr. de Haas' analogy is somewhat misleading. The main point of my article was that deuterium is an inherently poor fuel. In other words, William would have been critical of Orville and Wilbur if they had tried to build a coal-powered airplane. The right choice leads to the right solution—witness the fact that current airplanes are still burning liquid hydrocarbon fuels. If I wanted to continue the analogy, I would postulate a cast of thousands working for 25 years on a government-funded program to develop a coal-fired, cast-iron biplane. If these scientists stayed on the fusion schedule, they would be getting ready to prove the scientific feasibility of coal-fired flight just about now, with the first commercial coal-fired biplane scheduled for introduction in about 2025.

Drs. Dean and Cohn offer two versions of the same argument: that the economics of fusion are within range of projections for fission and other power sources of the next century. I chose to compare current fission and fusion technology to avoid the obvious uncertainty of projecting future costs. A relative ranking is much less sensitive to error.

The same point applies, of course, to Dr. Cohn's comment regarding the low power density of hydrogen-boron systems. Relative power density is important when comparing complex radioactive power plants, but not when comparing those plants with a nonradioactive fusion system where the scale and heat-removal techniques could be completely different.

Finally, I must agree with Dr. Goldman that I did not adequately differentiate between high-level and low-level wastes. There are certainly responsible members of the "nuclear community"—Dr. Goldman himself is an example. But the fact remains that several organizations, including Livermore National Laboratory, have advocated direct underground disposal of high-level liquid wastes. Oak Ridge National Laboratory actually disposed of high-level liquid wastes in shale deposits, disposal beneath arctic icecaps was seriously considered, and the military continues to store immense quantities of corrosive, high-level liquid wastes in steel tanks. I think that record has obscured the fact that the technology for safe waste disposal has essentially been devised.



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